B. M. Parakhonskii, Technical-Economic Problems of Air Transport,
(Tekhniko-Ekonomicheskie Problemy Vozdushnogo Transporta)
USSR Academy of Sciences, Institute of Complex Transportation
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INTRODUCTION

Air transport in our nation was created completely during the years of the Soviet government. The start of its development came in 1923 when the first air line was opened between Moscow and Nizhnii Novgorod (now Gor'kii).

Since then a wide network of all-Union as well as international air lines has grown up.

The latest period has seen large works of reconstruction and building of airports. Concrete runways, necessary for contemporary planes,* have been built at many airports; air routes are equipped with the latest radio and lighting devices, which have considerably widened the network of night air communication and heightened the regularity of flights. Many new airports, each with a large traffic capacity, have been built along the major air lines. Our nation's aviation industry has supplied air transport with a large fleet of transport planes. And there is an adequate amount of qualified flight and technical personnel.

USSR air transport occupies second place in the world in total volume of hauls (in ton-kilometers), yielding only to the USA. Its share in serving passenger travel in the USSR is gradually increasing, especially for long distances. Air transport plays an important role in hauling mail and printed matter. The significance of transport aviation is growing in regions of the Soviet Union which has few roads, especially those in the northern and northeastern oblasts.

The utilization indicators of the airplane fleet have increased considerably as a result of steps taken to better the organization and to perfect methods of operation. The average annual flying time of a written-off plane on an all-Union line has increased during the period 1952-1959 by more than 50 percent. Decreases in the volume of hauls during the fall-winter period are successfully being overcome. Comparing the totals of the first and fourth quarters of 1940 and 1959, utilization was only 34.5 percent in 1940 but rose to 43 percent in 1959.

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*[Ed. note: As used in Soviet transportation terms, "contemporary" usually means the modern turboprop and jet aircraft.]

The prime cost* of hauls on air transport is rapidly decreasing because the industry has provided new, more economic types of planes, better technical-economic indicators of the exploitation of the fleet, increase in volume of hauls, and greater labor productivity of workers. Prime cost has decreased four-fold in the period 1932-1959, and profits from hauls exceed operating costs.

Still, the present level of USSR air transport development is inadequate, and the degree of technical equipment of a number of air routes does not correspond to contemporary requirements.

USSR air transport growth rates during the first decade after the end of World War II were somewhat lower than the growth rates of air transport in the capitalist nations. Between 1945-1955 USSR air transport has increased passenger hauls 4.8 times, passenger turnover 5.8 times, and mail/freight turnover 4 times.** During these years the total volume of hauls by air transport in capitalist nations increased 7.5 times in passenger hauls, passenger turnover increased 7.7 times, and mail/freight turnover 7.2 times.*** In the USA passenger hauls rose 5.8 times during the period 1945-1955, and passenger turnover rose 6.2 times.

The sharp rise in growth rates of USSR air transport began after the Congress of the CPSU and its decision about the necessity of further increasing the technical level of all forms of transport, and the introduction of fast multi-passenger airplanes. During the period 1955-1959, air passenger hauls increased by 384 percent, and passenger turnover by 226 percent. Air passenger hauls in capitalist countries during the same period increased by only 41 percent, and passenger turnover by 53 percent. The growth rates of air hauls in the USA were even lower. In comparison with 1955, passenger hauls on U.S. airlines increased by only 34 percent in 1959, and passenger turnover by 49 percent.

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*[Ed. note: prime costs, as used in this study, includes labor, materials, supplements, and depreciation (where charged)].

**Transport i sviaz' SSSR. Statisticheskii sbornik (USSR Transport and Communication. Statistical Handbook). Moscow, Gosstatizdat, 1957, p. 209.

***Interavia, No. 6, 1958.

Despite the high growth rates of USSR air transport during the past years, the servicing of the population by air hauls, according to the number of passenger-kilometers flown, is still lower than in a number of capitalist countries. During 1955-1959 the difference in volume of air transport passenger "production" per person of the population in the USA and the USSR has decreased considerably, although it continues to remain significant. The inadequate utilization of air transport for passenger hauls in the USSR is also evidenced by the fact that the share of air hauls in the total passenger transport turnover was 3.5 percent in the USSR in 1958*, and 37 percent in the U.S.

The incomplete meeting of the needs of our country's population in air communication is considerably qualified by the fact that far from all reserves have been discovered and employed. With continual growth in the volume of hauls the problem of increasing the utilization of the airplane fleet, while insuring the complete safety of air traffic, becomes especially significant. Still, the average annual flight time of a written-off airplane is lower than in a number of capitalist nations, especially the U.S., where it is around 2,500 hours annually.

Labor productivity of USSR air transport according to the indicator -- ton-kilometers flown per year per worker -- is lower than that of the U.S. This also indicates the huge reserves of our country's air transport for saving social labor and lowering the prime cost of hauls.

At the present time our country has everything necessary for speeding up air transport development. In 1956-1957 multi-passenger transport planes with gas turbine engines which do not cede to -- and in several significant indicators even surpass -- foreign-built airplanes, have been constructed under the leadership of airplane designers A. N. Tupolev, S. V. Ilyushin, and O. K. Antonov. Design bureaus headed by M. L. Mil and N. I. Kamov have constructed transport helicopters with various freight capacities. These are already being series-produced.

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*E. F. Rudoi, T. I. Lazarenko, Razvitie transporta i sviazi v SSSR. 1959-1965 (The Development of Transport and Communication in the USSR, 1959-1965), Moscow, Gosplanizdat, 1960, p. 47.

Together with this, the rapid perfection of radio- and lighting-technology gives reason to suppose that in the coming years air transport will become even less dependent on physical-geographic conditions. Therefore, such important operation indicators as regularity and continuity of traffic will increase radically. All this is creating new possibilities of widening air communication and considerably heightening its role in serving the needs of the USSR national economy for rapid transport.

The control figures for the development of the USSR national economy, 1959-1965, affirmed by the 21st Congress of the CPSU, foresee that air transport passenger hauls will increase by approximately six times during the seven years. Air transport will become one of the main forms of passenger transport.

The task of the present work is to point out the aspects and role of air communication in a single transportation network for the whole country, to determine the spheres of its efficient utilization, and to establish, in connection with this, economic demands of some indicators of the technical means of air transport.

Chapter I

TECHNICAL - OPERATING ASPECTS OF AIR TRANSPORT

The most important technical - operating features of air transport are:

1. Fast speed;
2. Little dependence on the terrain of the region, and as a result of this, a high passableness and shorter air routes, because they are straight in comparison to surface routes;
3. Great maneuverability, and the possibility of organizing through or direct communication;
4. Good adaptability to various sizes of passenger and freight flows;
5. High prime cost of hauls.

Let us briefly look at the characteristics of air transport and their influence on its operations and perspectives for future development. We find that it is better to conduct this analysis not according to air transport as a whole, but rather differentiated according to the different types of airplanes. The reason for this is the fact that within the entire air fleet there are various airplanes and helicopters which differ greatly in their technical and economic indicators. Often the differences between airplanes are considerably greater than those between airplanes and surface forms of transportation.

By comparing two types of airplanes -- the three-seater Yak-12, which has a speed of 120 km/hour and non-stop flight distance of 500 km, with the Tu-114, which can seat 220 passengers and develop speeds up to 800 km/hour, one is easily convinced that these are two very different forms of transportation.

The speeds of various forms of transportation can be compared according to the following data:

Means of Transportation	Speed, km/hour
Turbojet Tu-104	750-800
Turboprop Tu-114	750-800
Turboprop Il-18	600-650
Piston-type Il-14	320
Piston-type Li-2	240
" An-2	180
" "Pchelka" (Little Bee)	180
" Yak-12	120
Helicopter Mi-4	140
" Mi-1, Ka-15	110
Express train	80-100
Fast, long-distance train	50-60
Local Passenger train	30-35
Inter-city bus, ZIL-127	70
City and local bus	45
Vessel with submerged blades, "Comet"	70
Sea turbo-electric vessel, "Baltika"	37
River vessel, "Lenin"	26
River vessel, "Rossiia"	19

From the above data, air transport's advantage in speed is evident as compared to surface transportation. Compared to a fast, long-distance train, the piston-type Il-14's speed excells it by six times, the turboprop Il-18 by twelve times, and the turbojet Tu-104 or the turboprop Tu-114 by sixteen times. For short distance air communication airplanes of the An-2 and Li-2 types are primarily used: their speeds are, respectively, six and eight times greater than that of a local train.

The speed advantage of airplanes is even greater in comparison to sea and river vessels than it is to a train. The speeds of the An-2 and the Li-2 are approximately three times greater than the speed of an inter-city bus, and that of turbojets and turboprops is nine to ten times greater.

The advantages of air communication as compared to surface transport are even more significant in commercial speeds. Jet transport planes land after 2,000-3,000 km,* piston-type planes of the Il-14 variety -- after 800-1,000 km, with the stop at airports lasting from 30 minutes to one hour. Fast trains have stops every 100-150 km, while passenger and local trains stop several times more often. River vessels and buses have many stops.

For this reason the commercial speed of surface forms of transportation usually depends to a lesser extent on the technical factors than the commercial speed of airplanes depends on their cruising speed. Airplanes can fly thousand-mile routes non-stop. In such cases the commercial speed is equal to the plane's cruising speed.

Taking all factors into consideration it is possible to say that speed of communication by turbojets of the Tu-104 type and turboprops of the Tu-114 type exceeds the speed of railroad communication on a fast train by 25 times. This refers to air routes of up to 3,000 km (i.e., non-stop flights); when the distance is over 3,000 km, and requires stops, the planes exceed the train by 22-23 times. Turboprops of the Il-18 type on routes of 2,000-2,500 km distance (non-stop) exceed the train by 18 times, and piston planes of the Il-14 variety -- by seven times.

However, it is necessary to point out that in certain cases the above speed ratios must be corrected, because the airports are sometimes located further from the center of town than railroad stations. Therefore, passengers spend more time for the trip from town to the airport than they do for the trip to the railroad station. It is usually figured that the approach or access time (time needed to arrive at an airport or station) of an air transport passenger is approximately two hours -- one hour upon leaving, and one hour upon arriving, if the airport is 25 km from the center of town. But these average figures are not descriptive of the actual situation.

Accounts show that of the total number of airports of all-Union lines 60 percent are located at distances of up to 10 km from the

*In reference to distance, 1 km = 0.621 statute miles.

center of town, and 30 percent -- 10 to 20 km. Only 10 percent of all airports are located at more than 20 km from the center. To the latter belong airports in the following cities: Moscow (Vnukovo, Bykovo), Kuibyshev, Gor'kii, Baku, Vladivostok, Sochi, Sukhumi, Mineral Waters, and others.

Airports which serve small towns and regional centers are usually located no more than 3-5 km from the city limits, and no more than 15 minutes is usually needed by bus to get to the airport from town. In practical terms, this access time is not very different from the access time needed to get from town to the railroad stations, for these are also often located on the outskirts of town or altogether outside it.

In this fashion, the speed advantages of air communication in comparison with parallel railroad transport exist for all distances beginning with approximately 150-200 km, i.e., such a distance where an airplane can already save the passenger about 4-5 hours. With an increase in distance the economy in time with air travel grows quickly and reaches dozens of hours and days.

In perspective, the speed advantages of air transport will grow even more. This is tied with further progress in airplane construction and still greater speeds, as well as improvements in the organization of air communication -- straight air routes, fewer and shorter stops at intermediary airports, non-stop flights, and faster passenger communication from town to airport and back, partly through the use of helicopters.

The second peculiarity of air transport is specific dependence on natural conditions. This too is different for different airplanes. The influence of various atmospheric conditions on the utilization of air transport decreases with the latter's technical progress. Jets fly above the zone of atmospheric conditions, piston-type planes are being equipped with various devices which make flights possible during difficult meteorological conditions.

A far greater hinderance to air travel is difficult weather conditions upon landing (low clouds, fogs, snowfall). The regularity of air communication is disturbed when such conditions exist. Equipping airports with radio and lighting equipment has considerably lessened the

problem of blind landings. However, air transport has not yet achieved complete independence of meteorological conditions at landing and still depends upon the weather in many respects. Radio and lighting equipment for airports is complex and expensive; therefore only a limited number of airports, those serving the larger cities, have a complete set of instrument landing equipment. In the U.S. in 1957, for example, out of 2,600 airports and landing strips only 153 airports, or 5.9 percent, possessed such equipment.*

There is reason to suppose that in the future, progress in radio location and fog dispersion will lessen the influence of unfavorable weather conditions on the regularity of air traffic.

Climate also influences airplane utilization -- especially air temperature. In hot regions conditions for takeoff and landing are worsened by the thin air. This then requires enlarging the airports and lengthening the landing strips.

According to the standards recommended by the International Organization of Civil Aviation (ICAO), the required length of a landing strip for a plane is determined at an air temperature of 15°C for airports located at sea level. Depending on the actual temperature, taken as the average daily temperature of the hottest month of the year, it is necessary to correct the landing strip length by 1 percent of the standard length for each degree exceeding the given standard (15°C). The correctives for lengthening the landing strip, depending on the altitude of the airports, are 7 percent for each 300 meters of altitude above sea level. In accordance with this, the volume of construction work needed for building landing strips in southern regions, especially with their location far above sea level (with other conditions being equal), exceeds somewhat the volume of construction work in regions of moderate climate.

Low temperature also hampers the servicing of airplanes, and the utilization of some forms of piston-type planes becomes impossible at low temperatures (around -50°C). For this reason there are interruptions in air traffic in northern and northeastern regions of the country during winter months.

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*Statistical Abstracts of the United States, 1959, p. 577.

The adaptation of aviation technology for work at low temperatures is being conducted in several directions. New types of airplanes and helicopters are undergoing all-round tests in northern regions, and necessary changes are being incorporated into their design. Special types of lubricants are being used for engines, heating systems are being perfected, etc.

The dependence of air travel on the terrain of the country is determined by the flight altitude, which reaches 12 km for planes with turbojet engines, 8-10 km for turboprops, 3-4 km for piston types of the Il-14, Li-2, and 2-3 km for planes of the An-2 and Yak-12 type. Helicopters of the Mi-4 type reach an altitude of up to 6 km.*

The data on flight altitude allow us to evaluate the possibilities of every plane in surmounting the mountain relief of a region, while the indicators of a plane's non-stop flight distance indicate the possibilities of crossing deserts and seas.

Below are data on the practical distances of non-stop flight for some types of planes and helicopters (in km).**

Tu-114	about 8,000
Tu-104	" 3,000
Il-18	" "
An-10	" "
Il-14	" 1,500
Li-2	" 1,000
An-2	" 800
Yak-12	" 500
Mi-4 helicopter	" 500

Lengthening the distance of non-stop flight of transport planes to several thousand kilometers, heightening their dependability, substituting radio navigation for visual orientation, and a number of other improvements have created high passableness for air transport in all directions and have lessened the influence of natural conditions.

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*In referring to altitude, 1 km = 3,275.3 ft.

**This goes back to the use of km = 0.621 statute mile.

Because of this, airplanes have received great autonomy -- contact with the earth's surface is only needed for landings and take-offs, for refueling and lubrication, technical servicing and repair, as well as loading and unloading of freight and passengers.

On the average, USSR air routes are 20 percent shorter than the comparable railroad lines and highways, and 30 percent shorter than river ways. In a region with rugged terrain, air lines are sometimes more than twice as short as railroad lines. For instance, the length of the Irkutsk-Ulan-Ude line by air is 215 km, and by railroad 460 km; on the Adler-Krasnodar line these distances are respectively 235 and 547 km.

Because the route is shortened by plane as compared to surface means of travel there is a speed advantage with an air haul, and transportation work, expressed in ton-kms or passenger-kms, is lessened. Shortening of the route, therefore, has a double meaning: one, time is saved in traveling the distance, which is equivalent to a higher speed of travel; and two, transportation work is saved in transferring freight and passengers. It is necessary to keep the last condition in mind when comparing economies of transporting by various means of transport.

A third characteristic of air transport is a high degree of maneuverability and the possibility of organizing through travel. This is directly connected with the second characteristic, mentioned above, of the passableness of airplanes in any direction.

If the distance between airports does not exceed the length of a non-stop flight, this means that in practice there are no technical barriers to organizing regular air communication between these airports.

The possible number of air routes between airports will be determined in accordance with the equation of possible combinations:

$$S \text{ routes} = \frac{n(n-1)}{2} = \frac{n^2-n}{2}$$

where n = the number of airports in the territory.

No single surface system of transport possesses the possibilities of organizing through routes between populated points in any combination,

because this would require a tremendous building program of communication routes -- railroads or highways. The high passableness of air transport allows it to provide non-stop transportation to all more or less significant correspondences of passengers and freight, to efficiently utilize the airplane fleet with an irregular freight flow by way of such organization of flights which would bring to a minimum the length of empty (no load) destinations. If necessary, airplanes can complete round-trip flights between a number of airports corresponding in hauls. It is also extremely important that if necessary, airplane routes may be arranged so as to avoid stops at over-loaded airports.

A fourth characteristic of air transport is its adaptability to different volumes of passenger and freight flows. There is great diversity in passenger and freight capacity between airplanes. The number of passenger seats varies from two or three in a Yak-12 to 170-220 in a Tu-114, and the pay load from 0.2 to 30 tons (see Table 1). The range of productivity of an airplane is even greater due to the fact that those with greater freight capacity are also, as a rule, capable of higher speeds.

Table 1

GROWTH OF NUMBER OF PASSENGER SEATS IN TRANSPORT PLANES

Plane Designation	Year Came Into Use	Number of Passenger Seats
K-4	1929	3
K-5	1930	5
ANT-9	1932	9
Li-2	1940	15
I1-12	1947	21
I1-14	1955	24
Tu-104	1956	50
I1-18	1958	80-100
Tu-104B	1959	100
Tu-114	1959	170-220

Table 2 shows the productivity of several types of transport planes in passenger and freight hauls. It is evident from the table that the productivity of a plane of the Tu-114 type exceeds that of a Yak-12 in passenger hauls by 378 times, and in freight hauls by 1,000 times. The productivity of contemporary jets in passenger hauls is several times higher than the productivity of railroads, not to speak of river and sea vessels, and especially buses.

On the technical side, airplanes more than any other form of transportation are already adapted to serving mass passenger travel. The productivity of airplanes in freight hauls is large enough, although it yields significantly to the productivity of railroads and sea and river vessels. The capacities of airplanes have also grown. This allows special freight planes and helicopters to transport large, single-unit, bulky freights. We can point, for example, to the An-10, whose cabin can easily house automobiles and other large objects weighing up to 12 tons; the Mi-6 helicopter has the same weight and space capacity. At the same time there are planes and helicopters with a very small weight capacity. They are adapted for small or batch hauls as well as the transport of mail and medicines.

Speaking of air transport's adaptability to different sizes of passenger and freight flows one should also keep in mind that the utilization of fast, multi-passenger airplanes on short distance routes of 100-200 km is not efficient. Their tremendous transport capacity can be effectively realized only on long distances, serving the passenger turnover between points located no less than several hundred kilometers apart. More frequent landings at intermediary points will bring to a minimum the advantage of speed in jet airplanes and significantly increase the costs of hauls because of high expenditures connected with take-offs and landings. Dual engine planes seating 25-30 passengers or carrying 2-3 tons of freight have a greater flexibility of utilization, and intermediary stops do not effect the qualitative aspects of air communication very noticeably.

Table 2

PRODUCTIVITY OF TRANSPORT PLANES AND OTHER MEANS OF TRANSPORTATION

Means of Transportation	Speed (km/hour)	Commercial load		Productivity	
		Passengers	Total Tons	Passenger-km/hour	Ton-km/hour
Airplanes:					
Yak-12	120	3	0.2	360	24
An-2	180	10	1.0	1,800	180
Li-2	240	15	1.9	3,600	456
Il-14	320	24	3.0	7,680	960
Tu-104A	800	70	7.0	56,000	5,600
Il-18	650	100	14.0	65,000	9,100
Tu-104B	800	100	12	80,000	9,600
Tu-114	800	170	30.0	136,000	24,000
Express train	80	338	--	27,040	--
Fast train	50	720	--	36,000	--
Freight train with electric locomotive VL-22M	30	--	2,000	--	60,000
Bus, ZIL-127	70	32	--	2,240	--
Freight automobile of ZIL-164 type	50	--	4	--	200
River diesel-engine vessel, "Lenin"	26	465	330	12,090	8,580
Sea turbo-electric engine ship, "Baltika"	37	510	1,220	18,870	45,140

Sources:

V. Provorozhenko, I. Kostenko, et al., Transport SSSR, Moscow, "Morskoi transport" (Sea transport) Publishers, 1960; F. Kochnev, Passazhirskie perevozki na zheleznykh dorogakh (Passenger Hauls on Railroads), Moscow, Transzheldorizdat, 1959; V. Protasov, P. Sidorov, Ekonomika rechnogo transporta (The Economy of River Transport), Moscow, "Rechnoi transport" Publishers, 1958.

The average distance of passenger hauls by various forms of transportation in 1958 is characterized by the following data:

Type of Transportation	Average Haul of One Passenger (km)
Air transport, all lines	823
Including:	
all-Union lines	1,324
local air lines	146
Railway transport, all forms	86
Including:	
long-distance	484
local commuting lines	23
Sea transport, all-inclusive (not including Central Asian ships)	113
River transport, used in common by republics and Central Asian ships	39
Autobus transport, inter-city	28

The average distance then of one passenger haul by air transport, on all airlines, exceeds the average distance on railroads by almost 10 times, long-distance railroad hauls by 1.7 times, sea transport by 7.3 times, river transport by 21.1 times, and inter-city bus transport by 29.4 times. If we compare local air transport with inter-city bus transport, these being in the greatest interaction, then here too the average distance of one passenger haul exceeds by 5.2 times the analogous figure on inter-city buses.

The fifth characteristic of air transport is the possibility of quickly organizing it in unpopulated regions. Helicopters have the greatest potential, for they can complete flights from base airports to any point, without requiring specially constructed landing platforms. Airplanes require airports, the sizes of which depend on natural conditions and on the technical flight characteristics of the planes.

Equipment requirements for airports which are to serve multi-passenger jets are very high. The construction of such airports costs tens of millions of rubles and takes a long time. However, it is not necessary to construct and equip airports for the regular use of fast, high-capacity jets in order to satisfy the transport needs of newly

occupied outlying regions. Some lowering of the level of technical equipment on pioneer transport routes is not only possible, but fully justified from the point of view of the national economy.

Because of its speed of organization, air transport is ever more widely utilized in unoccupied regions, where it develops faster than other forms of transportation. We are speaking of those unoccupied regions where the creation of transport routes is a necessary prerequisite for beginning economic assimilation and settlement of the region. In our country one can see a picture of broad air transport utilization in roadless regions in the example of the Yakutsk ASSR, where the volume of mail-freight ton-kms per person of population is ten times higher than the volume of ton-kms per person of population in the whole of the USSR, and the volume of passenger-kms per person is respectively 8.5 times higher. For the sake of comparison we can draw on air transport utilization data for the past 15 years in Alaska where almost all populated points have regular air communication. In 1956 regular air service was carried out between 235 airports.*

Besides permanent airports, winter "snow and ice" airports have also been developed. Hauls into interior regions with landings at unequipped airports have taken place on a considerable scale. New methods of constructing snow and ice airports have furthered this, especially that of heating and melting the snow surface. Melting and then refreezing the snow gives the landing strip such a solid surface that it can support large dual-engine and four-engine airplanes.

Freight and passenger air hauls are rapidly increasing in Alaska. In 1958 air transport hauled 315,000 passengers in Alaska, as against 111,000 in 1948. The volume of transport work in 1958 was 48 million ton-km, in comparison with 18.7 million ton-km in 1948.** The volume of air transport work per person (of Alaskan population) is many times greater than it is for the whole USA. This is indicated by the following data (for 1958):

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*G. A. Agranat, Zarubezhnyi Sever (Foreign North), Moscow, Publishers AN SSSR, 1957, p. 98.

**American Aviation, April 22, 1957, pp. 10-11; Airlift, November 24, 1959, pp. 13-29.

Indicators Per Person	Interior U.S. Airlines	Alaskan Airlines
Passenger-kms	260.0	1,251
Freight and mail ton-kms	3.7	109

Source: Airlift, No. 24, 1959, p. 13.

In Alaska, air transport is widely utilized for freight hauls. Here there are 30 times more ton-kms per person than throughout the U.S., while there are only five times more passenger-kms.

Table 3

AVERAGE PRIME COST OF HAULS ON VARIOUS FORMS OF TRANSPORT IN 1958

Type of General Use Transport	Prime Cost, Kopeks		Prime Cost of Passenger-km, Percent of Ton-km Prime Cost
	1 Ton-km	1 Passenger-km	
Railroad	3.0	6.0	200
River Transport of RSFSR	2.6	10.8	415
Sea	2.4	16.0	667
Automobile	52.0	8.3*	16
Air	317.0	26.9	8.5

*in buses

Undoubtedly the utilization of air transport as a primary means of settling outlying regions of the USSR will grow in the future. The rapid progress of aviation technology, which finds expression in the creation of special airplanes, suited for use at small and simplified airports is aiding in this. Helicopters are achieving ever greater significance for transport operations.

The most important indicator of the efficiency of various forms of transport is the prime cost of hauls (see Table 3).* However, the data of Table 3 are not completely comparable. This is because on all forms of transport there are, besides expenditures which are a part of the prime cost of hauls, expenditures directly tied with the transportation process, but not accounted for in the prime cost. For example, in

*In this and following data all cost indicators are given in prices existing up to January 1, 1961.

river transport, the prime cost of hauls does not include the upkeep expenditures of the river ways; in sea transport the same is true of upkeep costs of route and port facilities. In automobile transport the prime cost of hauls does not include the costs for the upkeep of roads. On railroad transport the predominant part of loading and unloading work (over 80 percent) is performed by loaders and unloaders, and these expenditures are not part of the prime cost of hauls.

In 1959 the Institute of Complex Transport Problems (IKTP) of the USSR Academy of Sciences published a work on determining the national economic costs of hauling freight and passengers on the various form of USSR transport.* Determined in it are the ranges of digressions in haul costs to the national economy from the prime cost expenditures calculated by the ministries. Expenditures are more fully reflected in the prime cost of hauls by air transport. The expenditures not accounted for compose only 4.5 percent of the expenditures included in the calculation. On other forms of transport, additional expenditures not accounted for comprise from 23.9 to 42.1 percent of operating costs included in the ministries' calculation of prime cost. Therefore, the data of Table 3 provide only a general indication of the correlation in the prime cost of hauls, while the actual costs on surface transport are far less than air transport.

The prime cost level on various forms of transport depends on a variety of factors, the major ones being: (1) efficiency in utilizing the potential of the power sources, and (2) the correlation in the weight of packaging (construction) and the pay (commercial) load.

The efficiency of the power-source used in freight hauls, calculated in ton-km per 1 hp/hour, is lower on air transport than all the others. It is 25-30 ton-km per 1 hp/hour for a freight train; 40 ton-km for a sea freight vessel; 1.6 for a freight truck; and 0.3-0.5 ton-km for an airplane. For each ton of commercial freight on the railroads there is 0.8 to 1 ton of moving apparatus and service freight (fuel, etc.)

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*Ia. V. Shukstal', V. I. Zotikova, et al., Transportnye izderzhki v narodnom khoziaistve SSSR (Transport Costs in the USSR National Economy), Moscow, Publishers AN SSSR, 1959.

weight; on an automobile it is 1.6 tons; and on an airplane, depending on the type, it is 4-7 tons. When hauling passengers, air transport's efficiency of power source utilization is only 3-4 times lower than that of railroads. It is 4-6 passenger-kms per 1 hp/hour for the airplane, and for the train -- 16-18 passenger-kms.

There are 2 tons of construction weight for each passenger on railroad transport in the courier trains; in long-distance passenger trains -- 1.2 tons.* This correlation is more advantageous on air transport. On piston-type airplanes there is 0.4-0.6 ton of construction weight per passenger, and on turboprops of the tourist type -- about 0.3 ton.

Correspondingly, there is also a substantial difference in the prime cost of passenger and freight hauls. On air transport the prime cost of 1 passenger-km, given the weight of one passenger as 85 kg, is judged by GUGVF** to be 0.085 ton-km. In other words, the prime cost of 1 ton-km corresponds to 11.8 passenger-kms. On railroad transport the prime cost of 1 passenger-km is twice as high as the prime cost of 1 ton-km; in water travel it is 3.7 - 4.3 times higher. Only on automobile transport (in buses) is the prime cost of 1 passenger-km six times lower than the prime cost of 1 ton-km.

The given data on prime cost are averages for the whole network. The prime cost of a ton-km and passenger-km are substantially altered depending on the concrete conditions of utilization -- the type of moving fleet, region crossed, composition and distance of hauls, and their regularity.

The fluctuation of the prime cost of ton-km or passenger-km, depending on the type of airplane, is very great. If the prime cost of a ton-km for an Il-18 or Tu-104B is 100, then for a Tu-104A it will be 120-130 percent, for an Il-14 -- 150-160 percent, for an An-2 --

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*E. D. Khanukov, Transport i razmeshchenie proizvodstva (Transport and the Location of Industry), Moscow, Transzheldorizdat, 1956, p. 153.

**(Ed. note: These letters stand for Main Administration of the Civil Air Fleet which is charged with the legal and administrative responsibility for all civil aviation. In 1965 it became the All Union Ministry of Civil Aviation.)

280-300 percent, for a Yak-12 -- 500-600 percent, and for helicopters -- 1500-2000 percent.

Prime cost is substantially changed in relation to the region of the air route. Causes for this are different prices for oil products, varying costs of transporting fuel, lubricants, spare parts and other materials to airports, and severe fluctuation in wages by regions of the USSR as well as air lines.

The greatest range of fluctuation in expenditures is for fuel and lubricating materials. The standard price of airplane fuel and oil in belt V exceeds the price in belt 1, according to various grades, by 1.2-1.4 times. The transportation costs for delivering fuel and lubricating materials from railroad stations to airports fluctuate from 20 rubles per ton when the airport is located close to the railroad station, to several thousand rubles when fuel has to be delivered to outlying airports in some Northeastern regions of the Soviet Union. Calculations show that expenditures for fuel and lubricating materials per unit of transportation work for airplanes operating in the most outlying regions is 5-6 times higher than analogous expenditures for airplanes operating in the central and southern regions of the European part of the USSR. Expenditures for wages, running repair, and technical servicing per 1 ton-km are 2-2.5 times higher in outlying regions than in European regions of the USSR.

All in all, the prime cost of air hauls fluctuates from 95 kopeks per ton-km, or 9-10 kopeks per passenger-km on turboprops in a region of minimum operating costs, to 20 rubles per ton-km, or around 2 rubles per passenger-km, on a light piston-type plane in a region of maximum operating costs. This prime cost is calculated with the maximum commercial load and most advantageous flight distance for both types of airplanes.

In practice the range of differences in the prime cost of air hauls is even greater if we account for the fact that the actual commerical load is usually below the maximum. Since the prime cost of a ton-km is in an inverse proportion to the size of the airplane's

commercial load, the prime cost of one ton-km will double and become around 40 rubles for a light piston plane of the Yak-12 type with a pay load of 50 percent of the maximum in a region of maximum operating costs.

We can therefore conclude that one cannot compare the economy of air transport with other forms of transport according to average network indicators of the prime cost of hauls. The air transport fleet includes planes of various classes and types, those of the newest construction with high technical and economic indicators, as well as older, much less economical ones.

The high prime cost level of air hauls throughout Aeroflot is also conditioned by the fact that around 20 percent of the total volume of hauls of the Main Administration of the Civil Air Fleet is carried out on airlines in roadless regions (including the more outlying northern and northeastern oblasts of the USSR). The increase in the prime cost of air hauls in these regions is aided by the slight density of passenger and freight flows on large capacity local air lines, as well as such factors as the high costs of transporting fuel to outlying airports and the higher wages of Civil Air Fleet workers. Because of this, among the civil air fleet serving those regions there are many light, low-economy planes.

Constant flights to many points along the air routes of Eastern Siberia, Iakutiia, and the Far East are necessary not only to transport passengers and freight, but also to insure regular deliveries of mail in outlying points. On the other hand, with the utilization of freight planes of even such types as the Li-2, which are much less economic than the An-10 and Il-18 turboprops, the total costs of transporting freight by air are often lower than they would be by auto hauls. This explains the fact, for instance, that beginning with 1935 all the freight flow between Ashkhabad and Darvaza (above 25,000 tons annually) has been served by transport planes. Regularity in the flow of freight and the absence of seasonal fluctuations in hauls makes for a high productivity of the planes and a very low prime cost of hauls.

It is more correct, therefore, to compare the prime cost of hauls in different types of planes and various means of surface travel in concrete operating conditions. In long distance passenger transport one should compare the indicators of prime cost of a passenger-km in fast and courier trains with the analogous indicators in fast multi-passenger turbojets and turboprops. In short distance passenger hauls the appropriate indicators should be compared for local trains, inter-city buses and planes of medium and small capacity.

In regions where there are no railroads, where air transport is used for freight hauls, it would be correct to compare the prime costs of a ton-km in automobiles and in freight planes. Besides, in raod-less regions it is necessary to consider the local economic and geographic conditions of passableness of the communication routes.

CHAPTER II

THE ROLE OF AIR TRANSPORT IN A SINGLE TRANSPORTATION NETWORK OF THE USSR

1. PASSENGER SERVICE

Air transport is most widely used as a fast means of passenger travel. In contrast to other forms of transport, where freight hauls occupy first place, the main thing in air transport is passenger hauls.

With this it is characteristic that while the share of passenger hauls in the total work of air transport is slowly rising, it is decreasing on all other forms of transport (see Table 4).

In determining the structure of hauls on air transport, production is calculated by weight, given the weight of a passenger at 85 kg. and one passenger-km as equal to 0.085 ton-km. If we round this by taking one passenger-km as equal to 1 ton-km., then the share of passenger hauls on air transport will be (according to 1959 data) 95.4 percent, mail -- 1 percent, and freight -- 3.6 per cent.

One of the major reasons for the development of air transport as primarily passenger service is the fact that, in comparison with surface means of travel, the correlation in prime cost of air passenger hauls is much more favorable than freight hauls. On contemporary multi-passenger jets the prime cost of one passenger-km. is close to the prime cost of one passenger-km in a hard compartment car of fast trains,* while freight air hauls on the most economic planes are 35-40 times more expensive than railroad hauls.

The rates of growth of passenger hauls on air lines are considerably greater than those on other forms of transportation, as a result of which, air transport's share in serving the passenger turnover of the country is slowly increasing. In 1940 air transport had 0.2 percent

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*[Ed. note: Hard compartment means compartments with uncushioned seats.]

of the total passenger turnover, in 1950 -- 1.2 percent, in 1955 -- 1.6 percent, and in 1958 -- 3.5 percent.*

The given data cannot characterize the distribution of passenger hauls between air and surface forms of travel in concrete comparisons. This is because the number of populated points served by air transport is considerably less than that served by railroads.

Table 4

SHARE OF PASSENGER HAULS IN THE TOTAL TRANSPORT PRODUCTION
(in percent)

Form of Transportation	Year				
	1940	1950	1955	1957	1959
Railroad	19.1	12.8	12.7	11.2	10.3
River	9.6	5.7	5.1	4.9	4.1
Sea	3.6	3.0	2.1	1.6	1.2
Air	36.9	42.0	48.4	53.2	63.7

Source: Narodnoe khoziaistvo SSSR v 1959 g. (USSR National Economy in 1959), Moscow, Gosstatizdat, 1960, pp. 487 and 492.

In 1959 about 300 populated points were united by all-Union air lines. On the railroad network for passenger travel there are 11,823 stations, 10,109 of which serve long-distance passengers.**

Commercial stations on the railroad lines are situated at an average distance of 12 km apart; on the rivers, passenger piers are

*E. F. Rudoi, T. I. Lazarenko, Razvitie transporta i sviazi v SSSR. 1959-1965 (Transport and Communications Development in the USSR, 1959-1965), Moscow, Gosplanizdat, 1960, p. 47.

**Ekonomika transporta (Transport Economy), S. K. Danilov (ed.), Moscow, Transzheldorizdat, 1957, p. 271.

some 30-35 km apart; and intercity buses stop for passengers at each populated point along the travel route.

On the network of all-Union airlines airports are located at a distance of several hundred kms, and on the main trunk routes, they are still further apart. So, for example, according to the schedule of the Moscow-Vladivostok line, piston planes of the Il-14 type make a landing after 700-900 kms, and Tu-104s after 2,500-2,800 kms. On the Moscow-Tashkent line the Il-14s make two or three intermediate landings, while a Tu-104 covers the distance non-stop. On the Moscow-Ashkhabad line the Il-14s make two landings, and the Il-18s fly non-stop.

The common tendency, characteristic of long-distance air lines, is increasing the distance between stopping points. One reason for this is the ability of planes with gas turbine engines to fly greater distances non-stop. Economically, the most advantageous non-stop flight distance of the Il-12s and Il-14s is 700-800 kms, of the turboprop Il-18 -- 2,500-3,000 kms, of the turbojet Tu-104 -- 2,500-2,800 kms, and the turboprop Tu-114 -- about 4,000 kms.

Locating commercial airports at great distances from each other has an effect on the development of the economic gravitation zone of the airlines, and passenger flows on them. For all surface forms of travel the economic regions of gravitation represent a solid strip of territory located on either side of the railroad, automobile road, or river, for the great frequency of commercial stations allows the population living within the boundaries of this strip to utilize the services of the land and water routes. Therefore surface means of travel serve not only the areas between populated points, but also provide a passenger turnover between different oblasts and major economic regions of the country, that is, such service provides inter-regional communications.

Things are quite different with air communication lines. Airports of all-Union airlines are situated at such great distances from each other than an air route's economic region of gravitation is usually a sum of relatively limited (in size) zones of gravitation of two or

more airports. The boundaries of a passenger zone of gravitation to airports include the city and its surrounding areas, which can be determined fairly certainly by using the scheme of suburban railroad and bus traffic and considering the end stations as the limiting boundaries. For this reason air communication mainly serves inter-point traffic and only a small part of the inter-regional.

Table 5 shows the changes in air transport's share of serving passenger travel in comparison with railroad travel.

Table 5

THE SHARE OF PASSENGER TURNOVER ON RAILROADS AND AIR TRANSPORT BETWEEN MOSCOW AND SEVERAL CITIES OF THE USSR
(percent)

Corresponding City	Distance from Moscow by Railroad, km	August 1957		February 1958	
		Railroad Share	Air Transport Share	Railroad Share	Air Share
Kazan	838	90.0	10.0	92.6	7.4
Sverdlovsk	1,691	77.5	22.5	78.4	21.6
Novoskibirsk	3,228	64.7	35.3	55.8	44.2
Tashkent	3,374	71.5	28.5	55.4	44.6
Ashkhabad	4,681	53.5	46.5	27.2	72.8
Irkutsk	5,068	57.9	42.1	43.5	56.5
Khabarovsk	8,535	52.9	47.1	42.3	57.7

Air transport's share of passenger hauls between populated points increases, as a rule, according to the increase in distance between them. On those routes where the saving in time is especially great, air transport's share of hauls in February 1958 even began to supersede the share of railroads. This was the result of a sharp increase in capacity because of the introduction of fast multi-passenger planes of the Tu-104 type, as well as lower rates in 1957-1958.

Air transport can be converted to inter-regional communication by broadening the economic gravitation zones of airlines, which represent the sum of the gravitation zones of several airports.

One way of increasing air transport utilization can be by way of a greater number of airports in the network of airlines. A greater density of airports in the territory will make for an increase in the number of populated points served by air transport. However, this form of development will require large capital investments in the construction of airports suitable for main line airplanes; besides, the effectiveness of these investments will not always be adequate, because the overwhelming majority of cities with large populations is already served by airports of all-Union significance. (See Table 6.)

Airlines connect the larger cities of the Soviet Union, therefore the percentage of population served is considerably higher than the percentage of cities served. In the future the network of airports will be broadened primarily because cities with smaller populations will gradually be included into the number of populated points served by air transport. For this reason the effectiveness of new airport construction, from the point of view of population, will be lower than in previous years, when airports were constructed in the largest populated centers of the nation, with the largest passenger turnover.

From this it is clear that further airport construction, even though it is necessary, cannot fully solve the problem of satisfying the needs of the population in air transport hauls.

Another way to increase air hauls and improve the service to the population is to widen the airlines' regions of economic gravitation. To achieve this, the zones of gravitation of each all-Union line airport must be increased. Let us look at this question in greater detail.

When speaking of zones of gravitation of airports, it should not be supposed that their boundaries are firmly fixed. They expand with an increase in the speed of air communication on the one hand, and an increase in distance travelled by a passenger leaving from that

Table 6

ALL-UNION AIRLINES SERVICE OF USSR CITIES WITH A POPULATION OF OVER 100,000*

Population (thousands)	Total number of cities in USSR	Population of cities in 1959 (millions)	Of the total number of cities those served by airlines	Population of cities served by airlines (millions)	Percent Served by Airlines	
					Total number of USSR cities	The cities' population
Over 500	25	24.8	25	24.8	100.0	100.0
300-500	18	6.7	17	6.3	94.4	94.0
200-300	29	7.1	27	6.6	93.2	93.0
100-200	76	10.5	59	8.3	77.6	79.0
TOTAL	148	49.1	128	46.0	86.5	93.7

*Population of the USSR is taken from the all-Union census of 1959.

airport, on the other. This stems from the fact that air transport is used primarily as a fast means of transportation, i.e., only when the passenger can achieve an economy of time. With an increase in the distance of hauls, the possibility of this economy will increase, for in the total travel time, the share of access time decreases. Therefore, it is advantageous for the passenger to spend several hours for his trip to the airport (and sometimes even several tens of hours), in order to take a plane, which, during the rest of his route, more than compensates for the time spent in getting to the airport.

This is asserted by the example of air communication on Tu-104s between Moscow and Khabarovsk. Beginning in 1958 a great demand has been noted at these points for reservations on Tu-104s by passengers from other cities. Khabarovsk has received orders for seats from points all over the Far East, including the Magadansk oblast and Sakhalin; while Moscow has received orders from many cities in the European part of the USSR. How great the share of passengers from other cities is can be seen from the following data. In 1959 the Khabarovsk airport sent 48,000 passengers to Moscow, only 46 percent of whom were of local origin; whereas 54 percent were transitory, having arrived from other cities of the Far East.

In this manner, airlines which connect populated points thousands of kilometers apart (several days of railroad travel being required to cover them), can serve not only to connect terminal cities, but to an ever greater degree the inter-regional passengers. As air transport is better able to serve the long-distance inter-regional passengers, the greater will be the network of airport access lines of populated points whose airports are connected by main line airlines, and the greater will be the speed advantage of airplanes over parallel surface means of transportation.

The network of access lines, including all forms of transport (railroad and bus roads, water ways, local airlines), can broaden the gravitation zone of an airport by attracting long-distance hauls to the boundaries of various oblasts, administration economic regions and even republics. Such conditions now exist for airports located

on the fringes of our country. We can cite as an example Petropavlovsk in Kamchatka for the Kamchatka oblast, Vladivostok for Primorskii krai, Stalinabad for the Tadzhik SSR. Each of these cities is the main junction of a large number of access lines, and therefore the gravitation zone of their airports is quite large. Even with a relatively small population in the central point itself, its significance as a passenger center of the air transport network can be quite important if it is a large junction of railroad and bus roads, river ways and local airlines.

An analysis of the data on hauls shows that the 20 largest railroad stations, by number of long-distance passengers dispatched, are accompanied by only nine airports. Among the 20 largest (by passenger turnover) airports are resorts -- Sochi (Adler), Simferopol', Mineral Waters, and such points as Khabarovsk, which occupied fiftieth place on railroad transport, Krasnoiarsk (53rd place), Alma-Ata (66th), and Ashkhabad (143rd). All of these airports are either large junctions of various transportation lines, or else outlying district centers -- final points of air transportation.

When considering the problem of the distribution of main line airports in the perspective plan of air transport development, it is necessary to consider not only the population at the point of the future airport location, but also its significance as a junction of various transportation lines.

It would be incorrect and methodologically not permissible to draw an analogy between the passenger flow along railroad and air transport lines, and to take the passenger turnover of railroad stations at one point as a basis for calculating the possible volume of an airport's passenger turnover. The share of passengers dispatched by air as compared to that by railroad varies very significantly, and was, in 1958, for example, in Leningrad and Gor'kii around 2 percent; Moscow, Rostow, Sverdlovsk, Kuibyshev, Baku -- from 4 to 5 percent, in Irkutsk, Alma-Ata, Tashkent -- 10 to 12 percent and in Khabarovsk and Ashkhabad -- 17 to 18 percent.

Of great significance for enlarging the sphere of air transport utilization is the organization of combined transportation -- air-railroad, air-water, and air-automobile, which will make for faster passenger transport.

In order to organize an effective combined passenger transportation system it is necessary to insure at the junctions a minimum expenditure of time by the passengers for changing from one form of transport to another (from the railroad station or pier to the airport, and back). To accomplish this, inter-city communication will have to be improved in a number of cities, including, in perspective, the use of helicopters.

It is necessary to coordinate in time the operations of the various forms of transport, i.e., coordinate their schedules. Other factors must also be brought into consideration, for instance, the use of a single ticket on various forms of transportation; coordination of rates; unification of rules for the transportation of children, baggage, loads carried by hand; prior reservation of seats on the busiest lines in periods of seasonal passenger rush, which would guarantee the transit passenger a reserved seat on another form of transportation.

The primary means for bettering the service of the population by air transport is the creation of a single network of airlines, in a technical sense, which would include local as well as all-Union lines. The creation of a single network of airlines and the organization of combined transportation with the participation of other forms of transport will make it possible to serve the population by air on an ever greater scale, bringing long-distance passengers to the cities which have airports.

One can forecast with some certainty that after 1965 almost all the people who travel by railroad for a distance of over 3,000 kms will also have the choice of using air transport, because the distance from their place of residence to the airport will be covered in a very short time on the access routes (including local railroads, buses, planes and helicopters). The proposition is illustrated by the following figures: A fast train can cover 1,000-1,200 kms in 24 hours.

Therefore it will take around 2.5 - 3 days to cover the distance of 3,000 kms. Main line planes of the Il-18 and Tu-104 types, which fly at speeds of 600-800 km/hour can cover the whole route in 4-5 hours. In this case, even if it takes 20 hours to reach the airport, and this corresponds to at least 500 kms on a local train or inter-city busy (not to mention local airline planes and helicopters), the passenger completing his journey on combined forms of transportation will still save about two days as compared to the same journey in a fast train. Naturally, with such conditions, airports which have a gravitation zone of 700-800 kms in diameter will be serving not only the inter-point connections of cities, but the greater part of inter-regional passenger turnover as well. It appears that up to 1965 air transport will be able to serve the passenger turnover between economic regions approximately 4,000-5,000 kms apart.

According to the above, then, we can conclude that methodology now in use for calculating the volume of passenger hauls, based on an analysis of inter-point passengers, is useful for connections of 4,000-5,000 kms until 1965, and for subsequent years -- for distances up to 3,000 kms. To calculate the volume of passenger air hauls beyond these ranges, we must use the data on inter-regional communications, that is, the passenger turnover of economic regions, krais and oblasts. From this total passenger turnover, we can determine the potential volume of air passenger hauls, depending on the number of main line airports in the region, and the presence, condition, and prospective development of access routes to the transport junction. We should keep in mind that the future share of air hauls will grow continuously with enlargement of the access routes, better organization of combined communication, and an increase in speed of the means of air travel. The fact that air transport has begun serving inter-regional passenger turnover creates the premise for concentrating passenger flows along the major airlines. The amount of concentration of these flows depends on the total volume of passenger turnover between regions, this being conditioned by a number of economic, cultural and other factors, as well as the distance between regions.

The significance of this concentration is quite great. It will allow air transport to effectively utilize a large capacity, high speed airplane on an ever larger scale. It is known that the largest airplanes have a minimal prime cost of operation on the basis of 1 ton-km or 1 passenger-km. For this reason, a wider utilization of them will be economically significant and will allow for air hauls with minimum operating costs.

One can judge about the possible savings to be achieved per haul with the use of large airplanes from the following model calculations. With equal conditions of use a contemporary turboprop carrying 180-200 passengers has a prime cost of about 10 kopeks per 1 passenger-km, on a plane carrying 80-100 passengers it will be about 12 kopeks, and on one for 40 passengers, around 16 kopeks. Therefore, each billion passenger-kms completed on a plane of the first type will require 100 million rubles, the second -- 120 million rubles, and the third -- 160 million rubles.

When larger planes are utilized greater air communication speed is achieved because of the greater technical speed and longer non-stop distances; this leads to a smaller number of intermediate stops, i.e., to a greater commercial speed. With a Tu-114, for example, it is possible to organize inter-regional express service across the whole territory of the Soviet Union with no intermediate stops, or else with just one.

Air transport will be able to effectively serve population centers between the major economic regions of the USSR, usually at least 3,000 kms apart, and sometimes less if one takes into consideration the configuration of the network of surface transportation. One should include in the number of inter-regional communications which can efficiently be served by air transportation, the connections of Trans-Caucasia with Central Asia, and Kazakhstan or Northern Caucasus with the same regions, even though the distance between these economic regions is less than 3,000 kms.

Of the 240 connecting routes between 16 major economic regions of the USSR, somewhat more than half will be served by air transport. In the other inter-regional communications air transport will insure primarily the inter-point passenger connections.

The data presented about the possible number of inter-regional connections which can be viewed as being within the sphere of air transport operations, are conditional to a certain extent. Some major economic regions are so large that it is impossible to include them in the gravitation sphere of one airport, serving inter-regional communication. Such economic regions include, for example, Kazakhstan, Western Siberia, Eastern Siberia, and the Far East, where distances between each region's boundaries reach up to 2,000-3,000 kms, and the territory measures several million square kms. When territories are that great, inter-regional communications must be served by several, rationally distributed airports, which are equipped to handle main line long-distance airplanes.

The time savings achieved with air transport over large distances allows one to suppose that air communication will occupy a leading role in passenger hauls in the inter-regional exchange, and must replace fast, long-distance railroad passenger communication. Besides the airlines serving the inter-regional exchange, it is necessary to considerably widen the network of airways connecting the administrative, economic and cultural centers.

It is most difficult to determine with satisfactory accuracy the minimal distance of rational utilization of air communications for passenger and mail hauls. It depends not only on the type of airplanes and their operating conditions on a given route, but also on the surface means of transportation, parallel to the air route.

It is usually considered that the speed advantages of air transport cannot be realized at short distances, where surface means of transportation, which have a lower technical speed than airplanes, can still supply fast speeds for hauls between corresponding points. This is usually tied in with the fact that railroad stations are

located closer to the center of the populated point than airports, and bus stations, as a rule, are located in the center of town. Another fact is that on short routes the speed of air transport is considerably lowered because much slower airplanes are used than those flown on long-distance routes.

But one cannot agree with this, for on short routes, the speed of surface transportation is also lowered. On railroads the speed of local trains is only 29 km/hour, and the average speed of long-distance trains is 50 km/hour.* Consequently, a passenger can cover a distance of 300-350 kms in 10-12 hours.

The speed of inter-city buses, equal to 80 km/hour on a highway, is considerably lowered upon leaving and approach a city, and reduced still more on city streets. According to the schedule of an inter-city bus on the Moscow-Khar'kov route the technical and commercial speed on separate sections of highway fluctuates considerably (see Table 7).

Table 7

SPEED OF INTER-CITY BUSES ALONG THE MOSCOW-KHAR'KOV ROUTE

Section	Section Distance	Technical Speed		Commercial Speed	
		ZIL-155	ZIL-127	ZIL-155	ZIL-127
Moscow-Tula	180	42	49	39	44
Moscow-Orel	363	43	55	35	43
Moscow-Kursk	521	43	57	35	45
Moscow-Khar'kov	739	44	59	37	49

A distance of 300-350 kms can be covered by an inter-city bus passenger in 8-10 hours. On local airlines, using planes of the Li-2 and An-2 types, a corresponding route, probably shorter as compared

*Zheleznodorozhnyi transport (Railroad Transport), No. 3, 1958, p. 40.

to railroad and bus, will be covered in 1 to 1.5 hours, and when access time is considered -- in 2 hours, or 3 at the maximum. Therefore, a passenger taking a plane can save, in comparison with a train or bus, from 8 to 10 hours. In practice, this means that an air passenger can go to a point 300-500 kms from his residence, and return home in the evening, having spent the whole working day at his destination.

Any time savings during the trip is welcome to the passenger, if he is not encumbered with such inconvenience as several transfers, and if the difference in rates of air and surface means of transport is not too great. From the point of view of the national economy, the effectiveness of utilizing air transport on short routes in not limited to greater speed alone. In many directions the passenger flow is not large enough to adequately fill a whole passenger train, which seats several hundred people. Therefore local trains do not run often. Over 65 percent of all railroad stations have a turnover of one (or less) pair of trains in 24 hours, and 23 percent -- two pairs. So, at many stations (almost 90 percent) the traffic of local trains is very sparse. About 45 percent of suburban stations serve up to two pairs of trains in 24 hours, and about 60 percent serve up to three pairs.*

With such infrequent traffic, passengers lose a great deal of time in waiting for a train. With air transport, which has various capacity airplanes available, much more frequent traffic can be organized than on the railroads, thereby providing a great time saving.

Even bus transport cannot insure such frequency of traffic on little-used routes as air transport, for the minimal passenger capacity of contemporary buses is 20-22 seats (PAZ-651), while on an An-2 airplane it is 10 seats. One must also reckon with the fact that the network of roads in our country is not yet adequately developed, and the amount of bus lines connecting populated points is small. Air transport can insure communication in any combination along the shortest route between cities located "on the bottom of the air ocean."

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*Ibid.

Experience of the past years has shown that the population will gladly make use of air transport on trips of 100-150 kms, even when parallel railroad or automobile roads are available.

So, for example, the average distance of passenger hauls on local airlines of the Ukranian SSR was 124 kms in 1956, 104 kms in 1958; on local airlines of the North Caucasus Administration of the Civil Air Fleet these were respectively 122 kms and 105 kms. Within the Ukranian SSR, airlines with routes of 60 to 80 kms are operating successfully parallel to bus lines. Examples are the Khar'kov-Volchansk, Khar'kov-(East) Burluk lines and others.*

Air passenger hauls over short distances were hindered in previous years by the great difference in rates between air and railroad transport. According to the new system of rates, established by the Decree of the USSR Government, 31 August 1956, with amendments 28 April 1960, these hinderances have been eliminated to a considerable extent. Passenger air rates now are close to railroad rates. Table 8 shows the costs of a passenger ticket in an airplane and in a hard compartment railroad car.

At distances of 200 kms the cost of a plane ticket is only 6 percent higher than that for a compartment car. It is also important to note that a railroad line is usually much longer than a parallel air route. For this reason on a number of routes the cost of an air ticket, according to the new rates, differs little from that of a railroad fare, and at distances of over 200 kms flight is cheaper for a passenger than the same trip in a compartment car of a fast train.

The introduction of new air rates has led to a colossal growth in passenger hauls, especially on short air routes. The total number of passengers hauled in 1957 by Aeroflot increased by 70 percent in comparison to 1956; this includes a growth of 95.4 percent on local

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*A.F. Kompaneitsev, "Perevozki na mestnykh vozdushnykh liniiakh Ukrainy" in Organizatsiia perevozok i obsluzhivanie passazhirov na vozdushnykh liniiakh GVF ("Hauls on Local Airlines of the Ukraine," in Organization of Hauls and Passenger Service on Civil Air Lines), Moscow, RIO Aeroflot, 1958.

Table 8

COST OF PASSENGER TICKET FOR AIRPLANE AND TRAIN

Distance (kms)	Cost of Ticket, Rubles		Difference in Cost, Rubles	Air Fare as Percent of Rail
	Train	Airplane		
200	63	60	minus 3	94
300	76	90	plus 14	119
400	88	110	plus 22	125
1,000	154	230	plus 76	150

airlines. In 1958 and 1959 passenger hauls continued to increase rapidly. In 1959 they increased four-fold in comparison with 1956.*

In the spring of 1959 the use of turbojet aircraft was begun between Moscow and Leningrad at rates close to those of a compartment railroad car. As a result, air passenger hauls increased more than eight-fold in comparison with the previous year (1958). During ten months of 1959 Tu-104s carried 250,000 passengers between Moscow and Leningrad.

On airlines, as on railroads, the share of short-distance passenger hauls is quite large. It is characteristic that in the past few years the tendency has been towards increased use of air travel by passengers for short distances. Proof of this is a decrease in the average distance of passenger hauls on Aeroflot: 1,234 kms in 1955, 823 kms in 1958, and 784 kms in 1959. Looking at Table 9 one is easily convinced that air transport is mostly utilized for short distance trips. 45.2 percent of all air passengers make flights of up to 200 kms and 58.6 percent for distances up to 500 kms. However, in passenger-kms the share of short distance hauls is small. The share of passengers taking flights up to 500 kms is only 14.1 percent of total passenger-kms. The same condition exists on the railroads. (See Table 10.)

*Narodnoe khoziaistvo v 1959 g. (National Economy 1959), Moscow, Gosstatizdat, 1960, p. 531.

Table 9

DISTRIBUTION OF AIR PASSENGER HAULS ACCORDING TO DISTANCE TRAVELED IN 1959
(percent of total)

Distance (kms)	On All Airlines	
	Passengers	Passenger-kms
Up to 200	45.2	8.1
200-500	13.4	6.0
500-1,000	19.0	18.2
1,000-2,000	12.1	23.2
2,000-3,000	5.7	18.2
Over 3,000	4.6	26.3
TOTAL	100.0	100.0

Table 10

DISTRIBUTION OF PASSENGERS ACCORDING TO DISTANCE TRAVELED ON RAILROAD AND AIR TRANSPORT
(in increasing percentage of the total)

Distance (km)	Hauls by Air in 1959		Long-Distance Passenger Hauls by Railroads in August 1959	
	Passengers	Passenger-kms	Passenger	Passenger-kms
Up to 1,000	77.6	32.3	81.2	30.1
This includes:				
up to 200	45.2	8.1	49.8	5.4
up to 500	58.6	14.1	68.9	15.6
Up to 2,000	89.7	55.5	91.7	54.8
Up to 3,000	95.4	73.7	95.9	71.4
Over 3,000	100.0	100.0	100.0	100.0

Because of improvements in the organization of construction and industry, the administrative centers of enterprises and construction projects have been shifted over to the local level -- to the economic administrative regions. This will undoubtedly lead to a further increase in intra-regional hauls of passengers traveling on industrial business. An important problem for air transport is providing these hauls with a minimum time expenditure.

Serious preparation is needed to insure the satisfactory development of passenger air transport along short distances. It is necessary to have airplanes more adapted to local airlines service. They can have a relatively short non-stop flight distance, and, as a consequence of this, small fuel supplies; this will allow for increased commercial loads and a high economic rate of exploitation (operation).

According to verified accounts, existing rates for one passenger-km cover the expenses of hauls on Li-2s (the 21-seater variety), beginning with a flight distance of 70-80 kms. Therefore, from the point of view of insuring profit for air transport, the sphere of utilization of air passenger travel is acceptable at distances of up to 80 kms. With the modernization of the Li-2 and an increase of passenger seats to 24-28, this distance will be even smaller. The minimum distance of expedient use of air transport when utilizing vertical take-off devices can hardly be established at all. In 1959 in the U.S. 366,000 passengers were transported by helicopter an average distance haul of only 34 kms.* The use of helicopters for passenger hauls signalizes the "invasion" of the sphere of local and suburban communication by air transport, especially for providing communication between the business center of town and the airport, as is the case in New York, Chicago and Los Angeles. In Belgium, helicopters are also used for transporting passengers over short distances. Using the S-58, 12-passenger helicopters, Sabena Airlines completes communication between Brussels and eleven cities in four countries, including the air route Brussels-Paris, 300 kms in length. Helicopters maintain

*Airlift, No. 12, 1960, p. 74.

communication between the centers of cities, and, because this makes for a more straight-line course and faster speed (around 230 kms/hour) considerable economy in time is achieved in comparison with trains, which travel at a speed of 95-100 kms/hour.

The use of helicopters for communication between the center of town and airports, and transporting transit passengers from one airport to another within the boundaries of an air-transport junction appears further in the future. In the near future, however, helicopters will play an ever increasing role as auxiliary means of communication, completing routes by carrying passengers to airports for further continuation of their trip via airplanes.

The beginning of such helicopter service has already taken place and should now be combined with the new form of serving passengers -- i.e., the organization in large cities of downtown air terminals. With such service air transport passengers will arrive at the city terminal, and from there be transported to the airports and their planes. This is the most efficient, and fastest delivery of passengers to airports, and it will sharply reduce access time. The first experiment of such an operation is already in existence. In 1960 helicopter lines appeared in Moscow, connecting the downtown central air terminal of Moscow with the airports of Sheremet'evo and Vnukovo. This allowed for a 15 minute reduction in access time of Moscow passengers leaving via these airports.

Besides this, helicopters can play an important role in air communication in regions with a complicated relief, where it is difficult to locate a landing field for airplanes. During the years 1959-1960 several dozen helicopter lines were opened in our country in various regions -- the Caucasus, Central Asia, Siberia, and the Far East.

2. MAIL AND FREIGHT HAULS

Air transportation is being widely utilized for mail hauls. Mail, in a broad sense, includes letters, periodicals, printed matter,

money orders, packages, and newspaper galleys. The amount of mail in our nation is growing constantly (see Table 11). During the period 1940-1959 the volume of mail increased 1.6 - 2 times, and mail transported by air increased 6.8 times.

Table 11

DYNAMICS OF GROWTH OF MAIL DISPATCHED IN THE USSR
(in percent of 1940)

Year	Letters	Periodicals	Packages	Air Mail Hauls
1940	100.0	100.0	100.0	100
1950	99.9	87.6	95.6	210
1955	144.8	139.4	168.1	450
1956	151.0	156.2	168.0	530
1957	150.7	169.5	182.3	560
1958	154.5	181.0	195.6	610
1959	159.0	195.9	202.9	680

Almost all oblast, krai and republic centers are connected with Moscow by air mail. Over 1,600 farm regional centers have direct air mail contact with their oblast centers.

Air transport plays its most important role in carrying letters, the majority of which are transported by airplane. Main line mail, which includes letters transported between republic capitals, krai and oblast centers, is almost entirely carried by air transport, as is letter correspondence going to regions served by local air lines.

But, even with a large number of letters, their weight is much less than that of printed matter. In total weight of air mail carried, 6-7 percent are letters, 88-90 percent printed matter, and the rest packages.

Air mail flows are characterized by a great irregularity in destination. The dispatch of mail which consists mainly of newspapers,

concentrated in the centers (republic capitals and oblast cities), from where it is sent to the periphery. Newspapers are not transported in the opposite direction, and the letter correspondence is quite small in weight.

In perspective, one should expect the further increase in volume of air mail hauls. This increase is conditioned by the general growth of mail dispatches in our country, the further broadening of the network of air routes, and greater use of air transport for carrying packages. Still, it is necessary to keep in mind that the transporting of newspapers along main lines will decrease for several destinations in connection with the broadening of the publishing base and the increase in capacity of printing enterprises at local sites. Besides this, it should be considered that central newspapers will be printed in ever greater volume from matrixes in outlying cities. From the point of view of the national economy this territorial distribution of printing central newspapers has a great economic significance, for instead of daily hauls of dozens of tons of publications for distances of several thousand kilometers from Moscow, only matrixes are sent which weigh around 5 kg each.

The sphere of air transport utilization for freight hauls is much narrower than the sphere of passenger and mail hauls. The major disadvantage of air freight is its high cost. On the average the prime cost of one ton-km by air transport is 80 - 100 times higher than the prime cost of one ton-km on railroads or water transport. Therefore, air lines which run parallel to railroads and water ways carry only such freight whose efficient, quick-delivery value more than covers the higher cost of transportation. As selected data show, in the total volume of air hauls the major position is occupied by:

1) freight of technical items to supply industrial enterprises and new construction sites (the express delivery of spare parts, exact and measuring devices to enterprises of various aggregates);

2) perishables -- berries, fruits, early vegetables, fresh fish, game, various medicines, vaccines, serums, etc.;

3) expensive freight - precious metals and minerals, bank notes, objets d'art, precious furs, as well as movie films and samples of goods.

The volume of freight transported by air increases at a faster rate than that on other means of transport. Still, the role of air transport in serving the nation's freight turnover is very small; it consists of less than 0.05 percent of the total volume of freight hauls by all means of transport. In the next decade air freight hauls in regions having other means of transport will not play a noticeable role in the total transport network of the Soviet Union. But in a number of roadless regions air transport can occupy an important, and sometimes the major place in freight hauls.

The use of airplanes for hauling all forms of freight began over twenty years ago. In 1935-1937 freight planes of the PS-9 and G-2 type, with a freight capacity of from one to three tons had already begun regular freight hauls along air lines in the regions of Central Asia and northeastern USSR. The volume of freight flown along these lines amounted to tens of thousands of tons annually. For example, on the Ashkhabad-Darvaza route the volume of hauls in 1959 exceeded 25,000 tons. It is important to note that other forms of transport in various directions have been fully supplanted by air hauls.

In the Resolution of the XXI Congress of the CPSU, according to the speech of Comrade N. S. Khrushchev, "About the Control Figures of USSR National Economy Development for the Years 1959-1965," it is shown that with a regular increase in the volume of hauls it is essential to utilize those forms of transport which are most efficient economically for a given region and nature of the freight. Therefore, in determining the sphere of air transport utilization, it is important to select the correct conditions under which it will prove an efficient means for mass freight hauls.

In regions which are not served by railroads and water ways, the other possible form of transportation is automobile.* This requires

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*[Ed. note: Automobile is used in this study in the collective sense and probably includes all forms of truck and bus transport.]

the construction of highways or temporary winter roads, which are constructed in several northeastern oblasts of the nation. Air transport is used for hauls of mass freight, as experience has shown, in all cases when industrial development sites are located several hundred kilometers away from the major roads, and the territory separating them is poorly developed in the economic sense. In such areas any means of communication serve as bridges, connecting major lines with economically active points in the hinterland. Freight flows here originate and terminate in the final points, traveling straight through the complete route while local hauls are absent. Examples of this are the Askhabad-Darvaza lines, the end points of which are separated by the Kara-Kum Desert, and Chita-Tsipikan and other destinations in little populated mountain and taiga regions of Transbaikal. In such conditions one of the advantages of air transport is completely realized -- it doesn't require the construction of an expensive road.

All capital expenses for the permanent establishment of an "air bridge" are limited to the construction of two airports at the end points of the air line. The amount of capital investment in the construction of a highway, other conditions being equal, is directly proportional to its length, while the expenditures for the ground equipment of an airline remain unchanged for all practical purposes, for the non-stop flight distance of a contemporary transport plane usually exceeds the length of the required route. Therefore, with a lengthy route, the economy in capital investment for permanent equipment is much greater with air rather than automobile transport.

Naturally, when comparing the economy of air and automobile transport one cannot be limited simply to comparing the prime cost of hauls. Capital investments for the moving fleet as well as the permanent fixtures must also be noted.

The comparison of capital investments and operating expenses, with a consideration for the coefficient of effectiveness, will allow us to compare the economy of hauls by air and automobile transport and determine the most efficient sphere of their utilization.

Such a comparison, having illustrative significance, is presented for the conditions of the northeastern oblasts of the USSR.

The calculations are presented in two forms -- one uses a piston-type transport plane, the other a perspective turboprop plane. The costs of the airplanes are exemplary, determined by the level of world prices for foreign planes of their respective classes. The prime cost of one ton-km on the planes in the northeastern regions is given with a coefficient of increase from the average network prime cost. The construction cost of one airport is given as 25 million rubles, going on the assumption that an airport must have a minimum of equipment and be destined for freight, not passenger hauls.

For the sake of comparing air and automobile transport, the following original data is given:

I. On Air Transport*	Variant I (piston)	Variant II (turboprop)
Airplane productivity with 60 percent of commercial load and flight time of 1,500 hours a year, thousand ton-km/ annually	880	5,940
Prime cost of one ton-km with 60 percent commercial load without depreciation for renovation of planes, rubles	4	2.3
Cost of plane, million rubles	1.5	7
Cost of constructing two airports for the air route, million rubles	50	50
II. On Automobile Transport		
Productivity of ZIS-150 automobile, thousand ton-km annually		120
Prime cost of one ton-km without depreciation for renovation of roads, rubles**		1

*The length of the air route is given as 0.8 the length of a parallel highway.

**The prime cost of 1 ton-km of autotransport in the Yakutsk ASSR was one ruble, 62.4 kopeks in 1954 (Problemy razvitiia promyshlennosti i transporta Yakutskoi ASSR, Problems of Development of Industry and Transport of the Yakutsk ASSR), Moscow, AN SSSR Publishers, 1958, p. 381.

II. On Automobile Transport (Cont'd)	Variant II (turboprop)
Price of ZIS-150 automobile, thousand rubles	13.7
Cost of constructing one km of highway, thousand rubles	500
Expenditures for upkeep of one km of highway, thousand rubles	20

A method widely used in transport was employed to determine the sphere of efficient utilization of air and automobile transport according to cost indicators. All simultaneous costs for ground fixtures (airports and highways) and the moving fleet (airplanes and automobiles) were brought to a common denominator, measurable with the operating costs by using the coefficient of effectiveness of capital investments -- 0.1 (10 percent annually), corresponding to a ten-year period in which this is paid off.

The sum of the given operating costs and capital investments in each form of transport was determined for various volumes of freight flow annually and various haul distances. The results of the calculations are shown in Fig. 1.

When piston-type planes are used air transport is more effective than automobile transport with small freight flows. The sphere of its economically efficent use depends on the distance of the haul. With a distance of 100 kms air transport utilization is limited to freight flows of up to 10,000 tons. With a haul distance of 200 kms, air transport is more effective than automobile transport with a freight flow of about 20,000 tons annually. With further increase in the distance of hauls the limits of the efficient utilization spheres of air transport will widen somewhat; it is to exceed, however, a freight flow of 30,000 tons annually.

With the use of turboprops, which are characterized by significantly higher economic indicators, the sphere of efficient utilization of air transport reaches a freight flow of 50,000 tons annually with haul distances of 200-400 kms, and 60,000 to 70,000 tons in a distance range of 400-1,000 kms.

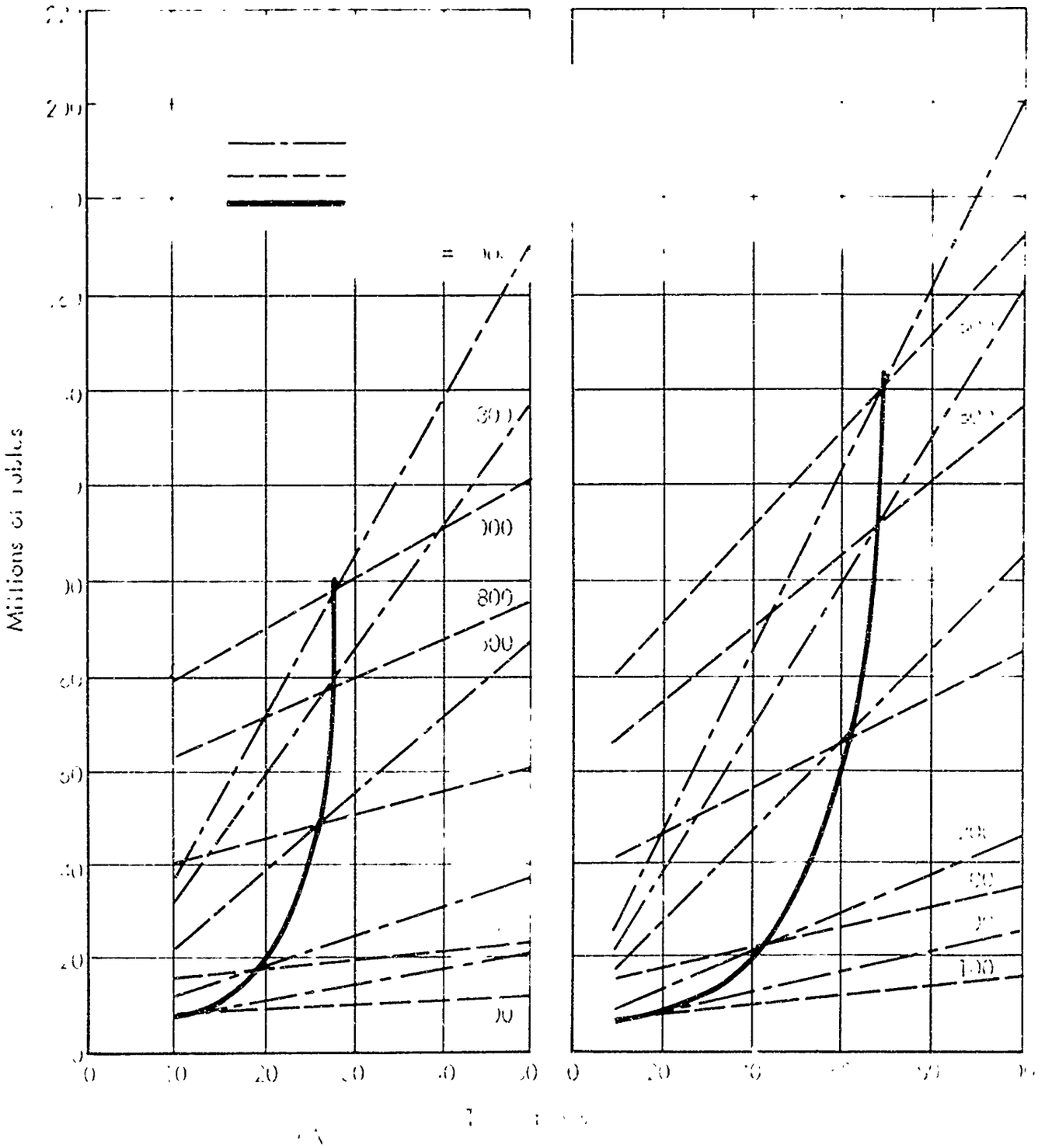

Fig. 1—Total costs of air and automobile transport with various freight flows and distance

Air transport of freight for short distances -- within the limits of approximately 100 kms -- can be economically effective when it surmounts the obstacle of mountains.

In those instances when the airport, situated on the major transport routes, is the center of several radial air lines going to points in the hinterland, the share of capital costs for ground equipment decreases accordingly. A fan-like network of air lines is most effective in economizing on capital investments in the construction of airports, and can increase somewhat the sphere of efficient utilization of air transport.

It is interesting to compare the given calculations with foreign data on the effectiveness of utilizing air transport for freight hauls. In Australia, according to Laight,* the gross cost of hauls (considering interest for capital invested in the ground equipment of air and automobile communication) with a freight turnover up to 20,000 tons annually will be lower on air transport than on automobile transport. Such a volume of freight flow is critical in the utilization of existing transport planes with piston engines and a 65 percent commercial load.

With the utilization of more economical, specially designed freight planes, air transport will be the most effective means of transport with a freight turnover up to 75,000 tons annually.

So, the view that air transport is at all times less economical than automobile transport is incorrect. It is based on the comparison of the prime cost of 1 ton-km on air and automobile transport according to data from the ministries. As a result of this, a psychologically unreceptive position is created towards air transport. However, if we consider the national economic costs of hauls, together with the capital investments, we will discover that air transport has a very definite sphere of efficient utilization. It is most effective in

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*B. Laight, A Review of Freight Aircraft, Proceedings, Institute Mechanical Engineers, 1955, No. 46.

distance ranges of over 400 kms, with freight flows within the limits of 30,000 tons annually for piston-type planes and 70,000 tons annually for turboprop freight planes.

Air transport can play an important role in the primary exploitation of natural resources of the hinterland regions of our nation.

Chapter III

PROBLEMS OF AIR TRANSPORT DEVELOPMENT IN THE USSR

1. THE DEVELOPMENT OF AIR HAULS

Air transport, as has been noted in previous sections of this work, is primarily a means of passenger and mail communication, and freight only on a small scale, while for all forms of transport freight is the major objective. It is evident from this that the development of air transport is directly tied to existing and prospective lines of passenger travel.

Factors which determine passenger flows are vastly different from those determining the volume and direction of freight flows. The latter develop between the production point and the point of distribution or consumption. With all the diversity of freight controls, all freight flows have in common the condition of clear-cut planning, depending on the complex of economic conditions determining their most expedient direction and routes to be followed from points of production to points of consumption.

Passenger travel follows its own rules, and large freight flows are seldom followed by a heavy stream of passengers. The major factors in the development of passenger travel lines are size of population at corresponding points, the distance between them, and a variety of other factors -- political, economic and cultural -- that determine population mobility at a given period, and the intensity of communication between the points.

A number of researchers have attempted to use mathematical formulas to show the dependence of passenger travel on the enumerated factors. The most famous formula in Soviet literature was presented by A. I. Zagorodan and F. P. Kravets*:

$$O = \frac{a_1 \cdot a_2}{r^2} \beta$$

*A. I. Zagorodan and F. P. Kravets, Passazhirskie perevozki (Passenger Hauls), Moscow, Transpechat', 1931, p. 132.

where

O = the number of passengers transported between two points, in one direction;

a_1 and a_2 = size of population at the points;

r = distance between the points;

β = coefficient determining population mobility at the given points.

This formula did not receive general acknowledgment, and its critics pointed mainly to vagueness in the method of obtaining coefficient (β). Possibly it would be more correct to substitute for the denominator distance squared, the time involved in travel between the two points, because the influence of increased transportation speed on population mobility is undisputed.

It is also necessary to take the factor of ticket price into account, keeping in mind that the share of expenditures for transportation in the private consumption fund of the population is fairly stable. Therefore the most obvious influence on population mobility is exerted by growth of the consumption fund (real income of the population) and an increase in the speed of passenger travel together with a decrease in the cost.

Viewing statistics on passenger transport, one can easily see a decrease in passenger flow with an increase in the distance between regions or different population points.

According to 1958 data, the intensity of passenger turnover* between the central regions of the USSR and the economic regions of the East varied in relation to the passenger turnover between the Center and Ural, taken as 100, in the following manner:

Center - Ural	100
Center - Western Siberia	38
Center - Far East	14

*Intensity of passenger turnover is determined by the number of trips annually per 10,000 persons of the population, as the quotient of dividing passenger correspondence between each pair of regions by the sum of their respective populations for any given year.

Passenger flow between various large centers also follows this pattern, which is evident from the following data about passenger departure for Moscow in August of 1957 (per 10,000 persons).

Point of Departure	Distance to Moscow by Railroad, kms.	Number of Passengers
Iaroslavl'	280	217
Gor'kii	442	169
Leningrad	651	132
Khar'kov	783	110
Sverdlovsk	1818	94
Cheliabinsk	2061	52
Novosibirsk	3340	41

The tendency toward a decrease of passenger turnover with an increase in the distance between the corresponding regions and population points has important significance for air transport. In the amount of time saved, the effectiveness of air communication is greater, the larger the distance. It is therefore natural that, other conditions being equal, air transport's share in the general passenger turnover will be maximum at long distance.

In this manner, the development of air passenger communication encounters the following contradiction. On the one hand, the effectiveness of air passenger transport increases with an increase in distance between the corresponding points or regions. On the other hand, the quantity of passenger turnover decreases with an increase in distance traveled. This contradiction will gradually decrease in the future.

As a result of perfecting airplane and helicopter equipment, and bettering their operation, the needs of the population will be better met. Just as railroads and automobiles prompted new passenger hauls, not possible with previous, primitive means of transportation, so air transport creates new objectives, new passenger travel flows.

The perspectives of air passenger transport development are tied with the general increase of passenger turnover in our country and with its future redistribution between various forms of transportation.

Following are growth indicators of population mobility in the USSR in non-city communication on common means of transportation.

Year	In Percent of 1950 Level
1950	100
1955	150
1960	183
1965	245

Population mobility has increased 1.8 times in the period 1950-1960, and, according to the control figures, will be about 2.5 times higher by 1965 than it was in 1950. Initial data for determining the general volume of passenger hauls as well as their distribution between the various forms of transportation after 1965 have not yet been worked out. We can assume that after 1965 the increase in mobility will continue, and that after a few years its level will be approximately twice as high as it was in 1955. We can also assume that after 1965 population mobility on the various forms of public transportation will increase at a slower rate than during the present seven-year span. This is connected with the expected further increase in the fleet of passenger automobiles and a corresponding growth of the role of automobile transportation in the passenger turnover between cities, especially for private trips.

A number of factors should be considered in making a prognosis of the future distribution of passenger turnover between various forms of transportation: operating costs of hauls, capital investment in the moving fleet and stationary equipment, time savings, and general considerations about the efficiency of utilizing various forms of transport for passenger and freight hauls.

Air transport, as the most accommodating for passenger hauls according to its technical-economic indicators, should, in perspective, show the highest rates of development, whereas railroad and water transport will specialize to a greater extent in freight hauls.

Table 12 shows the distribution of passenger turnover between various forms of transportation, indicated by the control figures of the Seven-Year Plan.

We can assume that after 1965 the share of the new types of transport will increase, and that at the next level air transport's share will reach approximately 30-35 percent of all passenger turnover. Air communication will become the major form of passenger transport in inter-city communication.

The determined volume of hauls presupposes a radical change in the distribution of passenger turnover among the various forms of transport. Towards the end of the Plan period, air transport, which now occupies the next-to-the-last spot, should take first place. With this, it is assumed that the absolute volume of hauls will increase on all forms of transport, except railroads, where stabilization will begin after 1965, and then somewhat of a decrease in passenger turnover in long-distance communication will take place. One factor slowing down this decrease will be a widening of the railroad network because of new construction.

Table 12

PASSENGER TURNOVER DISTRIBUTION IN INTER-CITY COMMUNICATION IN PERSPECTIVE

Form of Transportation	1958 (in percent of total)	1965
Railroad	86.7	63.1
Water	2.9	2.3
Bus	6.9	19.9
Air	3.5	14.7

Source: E. F. Rudoi, T. I. Lazarenko, Razvitie transporta i sviazi v SSSR (The Development of Transportation and Communication in the USSR), Moscow, Gosplanizdat, 1960, p. 47.

According to V. I. Petrov, the total of new railroad construction in the coming 15-20 years should be no less than 45-50 thousand kms.* Consequently, the railroad network may see a 40 percent increase by

*V. I. Petrov, Voprosy razvitiia seti zheleznykh dorog (Problems of the Development of the Railroad Network), Moscow, AN SSSR Publishers, 1957, p. 57.

1975, as compared to the present level, and reach some 170,000 kms. This would provide railroad service to the population in a number of new regions.

Growth rates of air passenger hauls in the U.S. are expected to be much higher than those in the U.S. Over 50 million passengers will already be using air transport in our country in the last year of the Seven-Year Plan.*

We can generally determine the prospective volume of mail and freight hauls by air, using the general growth rates of freight hauls on other forms of transport. However, we can safely assume that the prime cost of air freight will decrease at a much faster rate than the prime cost of hauling freight on other forms of transport. This will allow for a wider nomenclature of air-transportable freight.

An increase in the commercial freight capacity of airplanes will make it possible to transport large-size freights by air, in relatively large hauls, which would include complete sets of equipment for distant enterprises and construction sites.

Therefore, one must take into account a far wider use in the future of air transport as the pioneer means of transportation in the Asiatic part of the USSR, where, under certain conditions, it can become more efficient than automobile transport. Growth rates of freight hauls by different types of transport will not be the same. Sea transport will develop faster than railroad, and it is assumed that automobile transportation will develop at an even faster rate. We may assume that the growth rates of air freight hauls will not be lower, but rater somewhat higher than those of automobile transport, as was the case in the previous period. From 1940 to 1959 freight turnover on automobile transport increased ten times; on air transport it increased 19 times.** Despite this, the share of air freight hauls in the general freight turnover on all forms of transportation in the USSR will, in the next

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*Trud, 27 May 1960.

**Narodnoe khoziaistvo v SSSR v 1959 g. (National Economy of the USSR in 1959), Moscow, Gosstatizdat, 1960, pp. 511, 531.

decade, remain insignificant and will not exceed 0.1 percent of the total ton-kms hauled. It follows, then, that a possible error in determining the absolute volume of future air freight hauls cannot be of noticeable influence in solving the problems of establishing hauls on a national scale. In freight hauls air transport plays only a subsidiary role. It is only used for special rush hauls to destinations served by surface routes. Air transport can only play a pioneering freight transport role in areas which do not yet have roads.

2. PASSENGER FLOWS ALONG AIR ROUTES

Turning to the question of the distribution of air hauls (primarily passenger) according to the major destinations, we should note that one of the essential advantages of air transport is the possibility of organizing direct service between airports, in all directions and combinations, along the shortest straight lines. Such an organization of traffic is the most convenient. It eliminates the necessity of passenger transfers at key points, and makes the whole transport process easier and less complicated.

On the railroads there are a great many transfers from one train to another at junction points, because through trains only run between large passenger centers. Many long-distance passengers must make several transfers, which, as for example in Moscow and Leningrad, involve changing railroad stations.

However, the organization of through flights between any corresponding points is effective and efficient only if the passenger turnover is large enough. Since passenger turnover between two points decreases with an increase in the distance between them, the organization of through flights between distant points becomes economically inefficient. Under these circumstances the passenger volume becomes so insignificant that the frequency of flights would have to be reduced to an unacceptable minimum if the planes were to carry a normal commercial capacity.

Table 13 presents the total average daily passenger turnover on railroads and airlines between a number of large cities located far apart in a summer month when traffic is at a high level.

Out of the 96 connections in Table 13, 60 percent have an average daily (24-hour) departure of five or less passengers, and 30 percent have from five to ten passengers.

Table 13

AVERAGE DAILY (24 HOUR) PASSENGER DEPARTURES, TOTAL OF RAILROAD AND AIR TRANSPORT, AUGUST, 1957*

Point of Departure	Destination							
	Sverdlovsk	Omsk	Novosibirsk	Krasndiarsk	Irkutsk	Khabarovsk	Vladivostok	Tashkent
Kiev	25	8	10	7	5	7	9	17
Baku	3	2	2	1	1	1	1	7
Khar'kov	24	9	12	7	5	9	10	8
Gor'kii	23	7	14	7	3	5	5	8
Kuibyshev	25	11	14	6	4	5	7	75
Odessa	17	5	8	5	4	4	7	13
Dnepropetrovsk	8	3	3	3	2	2	3	3
Rostov-on-the-Don	12	3	10	3	1	9	6	5
Stalingrad	7	3	5	2	1	2	3	6
Saratov	9	4	5	4	1	4	4	15
Voronezh	7	13	6	5	3	3	4	4
L'vov	3	4	2	4	1	2	3	4

*The table is prepared on the basis of statistical data on the number of passenger tickets sold for railroad and air transport.

Even if we suppose that all passengers will use air transport, no more than two or three flights per month would have to take place in order to fill airplanes of the Tu-104 or Il-18 type, which seat 70-100 passengers. With such conditions, a train would arrive at the destination sooner than a plane.

The necessity of waiting for the next flight for 10-15 days will annul air communication's speed advantage and will make it practically useless. Extensive use of large-capacity passenger airplanes, therefore, will only be possible if air transport plays an inter-regional role in long-distance hauls, rather than an inter-point one.

Passenger communications, which in the future will primarily be provided by air transport, are connections between economic regions and oblasts of the nation located at a distance of 3,000 kms and more from each other.

The following must serve as a basis for determining the potential volumes of inter-regional passenger hauls by air transport:

a) data on regional passenger turnover during the past few years;

b) presumed changes in population distribution;

c) projected general growth rates of passenger turnover throughout the nation;

d) air transport's share in the total passenger turnover for the given years.

Passenger hauls are stable in direction. As a rule, passenger trips are executed in both directions, "there and back."

Figures 2, 3 and 4 show, in perspective, air passenger flows between economic regions of the USSR. The indicated flows should be viewed as an attempt at the closest approximation of the probable development rates of passenger turnover in our country after the present Seven-Year Plan. This prognosis, naturally, does not pretend to be based on absolute data; its major goal is to lay the groundwork for discussion of the difficult problem of perspective growth of passenger hauls in inter-regional communication.

The largest passenger flows connect distant economic regions of the Asiatic part of the USSR with the economic regions of the European part, especially with such large population regions as the Center, South and North-West. The maximum flow lines are those connecting the Center with Western Siberia, Eastern Siberia and the Far East. The

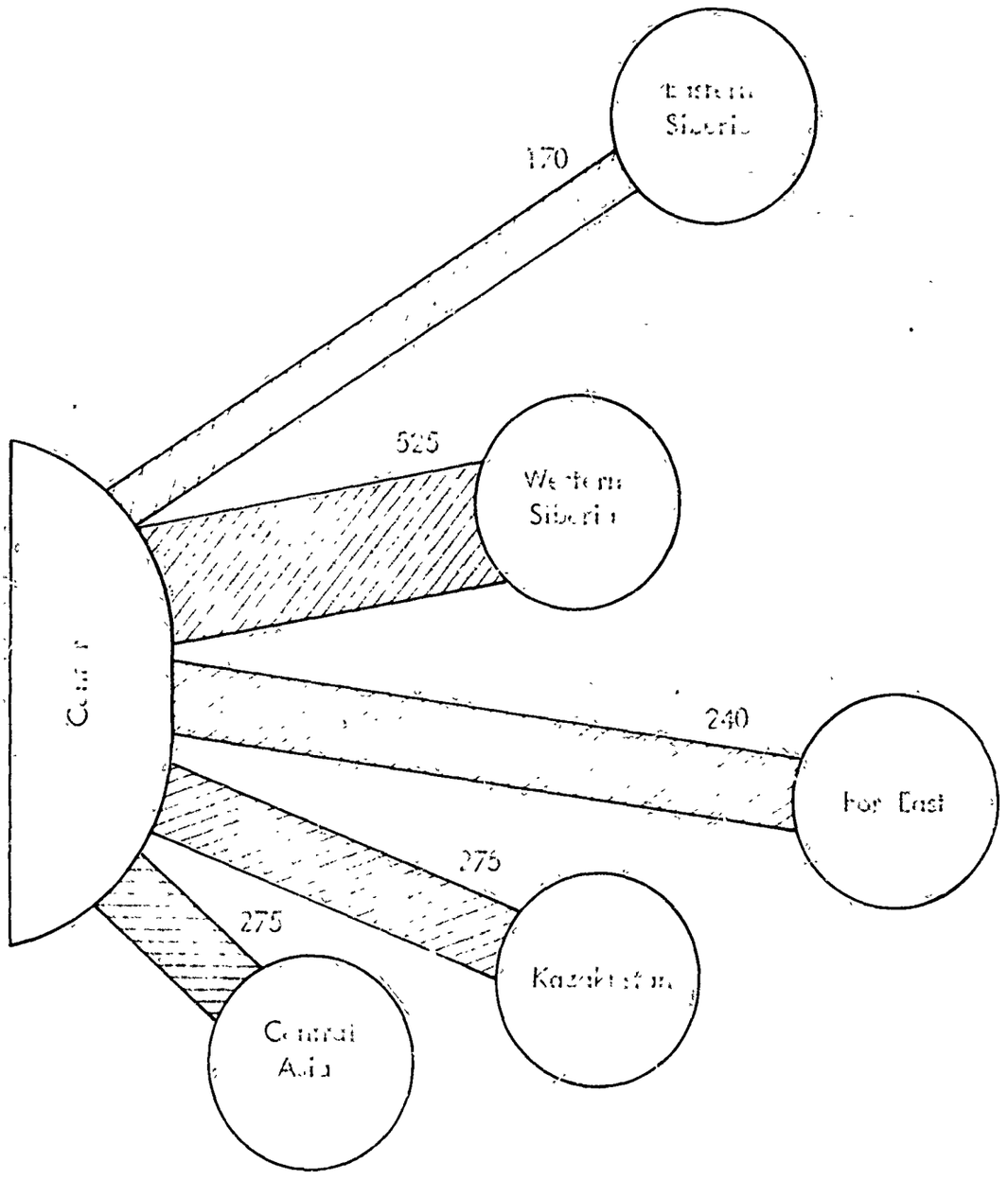

Fig. 2—Perspective air passenger turnover between the center and other economic regions
(in one direction, in thousand persons annually)

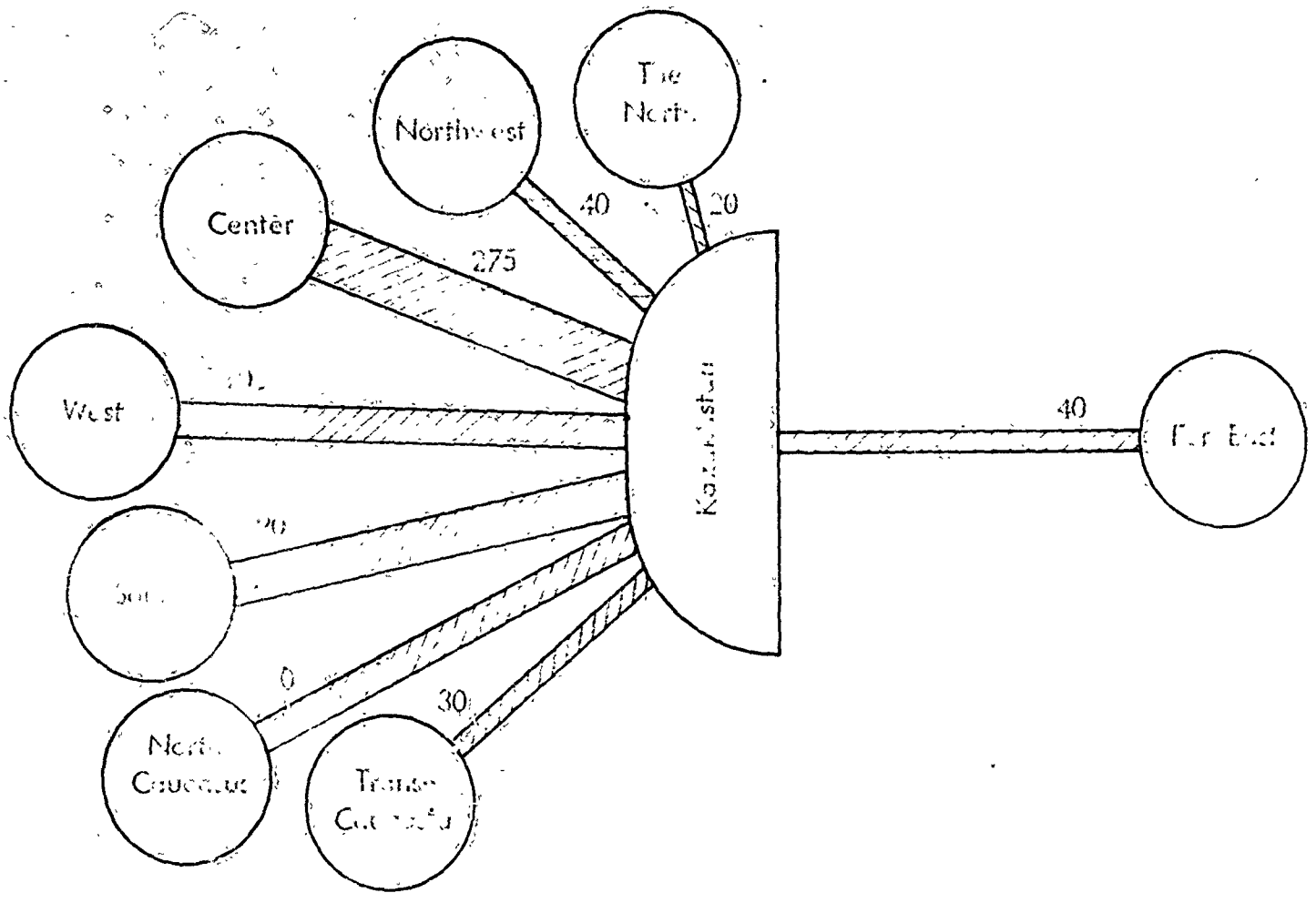

Fig. 3—Perspective air passenger turnover between Kazakhstan and other economic regions
(in one direction, in thousand persons annually)

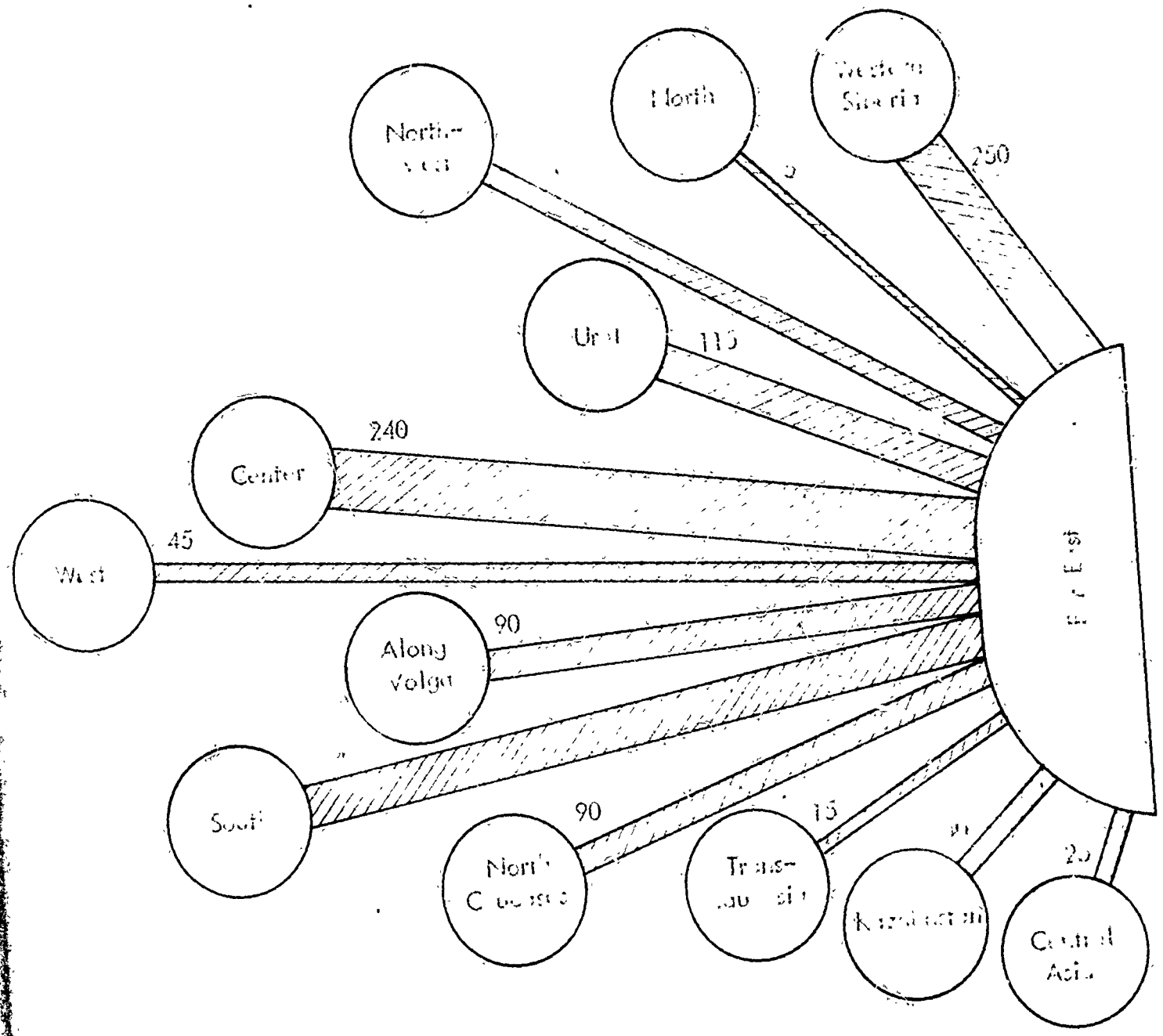

Fig. 4—Perspective air passenger turnover between the Far East and other economic regions
(in one direction, in thousand persons annually)

average daily number of passengers along these lines will be, respectively, about 1,500, 500, and 650 persons in one direction.* A relatively small number of passengers is expected along lines between such economic regions as the Far East and Central Asia; the Far East and Transcaucasia; Kazakhstan and the North; and Kazakhstan and Transcaucasia, where the daily number of air passengers in one direction is 30 to 50 people.

This passenger turnover volume is not sufficient for the organization of direct, all-year flights of multi-passenger jets. Therefore, the most efficient organization of passenger communication between the indicated economic regions would be through transit points with passenger transfers at airport junctions of neighboring regions. For example, the North's connection with other regions through the Center; the connections of Transcaucasia and Central Asia with Eastern Siberia; and the Far East through Western Siberia.

The sizes of air passenger flows noted above are only approximate, and require more definite computation and bases in the future. However, the general volumes and directions of passenger communications are well enough known to be able to determine the distribution of airports and the network of air communications for the near future.

3. POSSIBLE CLASSIFICATION CRITERIA FOR AIRLINES

The variety of forms of possible air transport utilization within the national economy makes it necessary to differentiate the activity of various airlines, determine their significance, and define the major parameters of the technical capabilities. This can be accomplished through a scientific classification of airlines, establishing uniform principles for grouping them and determining the technical characteristics of permanent and variable arrangements, based on the type of airline and volume of hauls.

However, the classification problem is quite complex. In the first place, air transport has not yet reached the level of technical

*This does not consider the coefficient of non-uniformity during different months.

stability of, for instance, the railroads or water transport. There is every reason to foresee radical changes in airplane construction in the near future, which will produce short and vertical takeoff planes. This will open a new epoch in airport construction, and will make it possible to bring airports closer to population centers.

In the second place, the technical level of airlines may require a corresponding rise, not just because of an increase in hauls, but also because of higher quality air transport "production" -- an increase in speed, constancy and regularity of communication.

In the third place, the equipment of airports should be determined not just by the prospect of air transport development, but also by the requirements of other forms of civil aviation: special purpose aviation, air survey, and medical services.

At the present time airlines are divided into two classes: all-Union and local. All-Union lines connect all-Union, republic, krai and oblast* administration, economic, and cultural centers. Local airlines connect rayons and populated areas with republic, krai and oblast centers, as well as with each other. International airlines which connect the USSR with other countries usually belong to the all-Union class.

This classification cannot be considered satisfactory. It is not enough to divide airlines into only two classes. Economic criteria, operating characteristics and major parameters of technical equipment corresponding to operating requirements are missing in the existing classification.

The present study does not include working out the whole problem of classifying airlines. Therefore the scheme of groupings presented here should be viewed as a draft only.

All USSR airlines should be divided into four classes (see Table 14).

First and second class airlines must connect about 100 of the most important political and economic centers of the Soviet Union. The major part of the work of air transport will be conducted along these lines.

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*[Ed. note: these are territorial subdivisions of a republic.]

Table 14

MODEL CLASSIFICATION OF USSR AIRLINES

Class and Designation of Airline	Classification Characteristics	Major Operating Days	Distribution of Airports and Demands on Them	Average Sizes of Passenger Hauls, Daily in One Direction	MAJOR AIRPLANE CHARACTERISTICS					
					Type	Number of Engines	Take-off Weight (tons)	Practical Flight Distance (km)	Cruising Speed (km/hour)	Load: Number of Passenger Seats / General (tons)
Class I. Express Lines	Providing long-distance communication between major economic regions of USSR, also transit communication across the Soviet Union and its international lines. Predominantly passenger hauls.	All-year, 24-hour service with maximum speeds, including supersonic.	At distances of no more than 2,000-2,500 km from each other, in large cities with population over 500,000 and in peripheral junction centers. Accept heavy planes with turbojet and turboprop engines.	over 200	TRD* and TVD	2-4	75-180	3,000-5,000	800-1,000 also supersonic	100-200 / 10-30
Class II. Main Lines	Connecting capitals of Soviet republics, industrial centers, all-Union resorts, serving inter-point and inter-regional communication. Predominantly passenger hauls.	All-year 24-hour service at high speeds.	In cities with over 200,000 population, resort and peripheral centers. Accept medium-weight planes with turbojet and turboprop engines.	over 100	TRD and TVD	2-4	30-60	1,000-3,000	600-800	40-80 / 12
Class III. Republic (Inter-regional)	Connecting republic capitals and kral centers with centers of autonomous republics and oblasts; also pioneer air lines in underdeveloped areas. Passenger, mail, and freight in roadless areas.	All-year, primarily daytime service. In roadless regions seasonal traffic of special freight planes along lines parallel to waterways.	In centers of krais, oblasts, autonomous republics, and cities with over 50,000 population, also in remote points	over 40, also freight up to 50-90,000 tons annually (in roadless regions).	TVD	2-4	10-20 freight up to 50 t.	600-1,000, freight up to 2,500 t.	300-600 freight at any speed which ensures minimal cost.	20-40 / 4-6, freight up to 12-16
Class IV. Local	Connecting oblast cities with regional centers and cities within the oblast; also serving suburban communication and rural medical needs. Predominantly passenger and mail hauls.	All-year, primarily daytime service.	In regional centers and city-like settlements with over 20,000 population.	From 10 passengers, plus mail (primarily printed matter).	IVD piston engine and helicopters	1-2	3-6	300-500	150-300	10-20 / 1-2

*On supersonic planes it is possible to install ram-jet engines (PVRD - DVRA) in combination with TRD - TRA.
TRD - Turbojet
TVD - Turboprop

Class I includes lines whose major function is the transportation of passengers and mail across large distances at the highest speeds. The time saved in long-distance flights will be considerable, and allows us to suppose that the express airways will assume a leading role in providing passenger travel for distances of 3,000 and more kilometers. Air communication will be able to completely replace rapid railroad communication (express and fast long-distance trains), and to accept all mail hauls. The primary demand made of Class I airlines is for all-year, 24-hour service at the fastest speeds possible. Considering the leading role of express lines in long-distance passenger service throughout the nation, we may expect that the volume of passenger hauls concentrated on these lines will be so great that it will be efficient to use the largest jets, such as the Tu-114, Tu-104A, Tu-104B and other modifications, as well as the Il-18.

Class II airlines principally carry passengers and mail. They may also carry considerable freight hauls (perishables and other urgent freight). A classification requirement of Class II airlines is also year-round, 24-hour service. The variety of purpose of Class II airlines and the diversity in volume of hauls do not allow for a clear-cut designation of airplane requirements. On a number of lines planes of large passenger and freight capacity are more efficient; on others medium-capacity planes are best.

Airlines of the first two classes must form the backbone of USSR air communications and establish a base for the development of republic and local lines. The latter perform the function of gathering and distribution lines from the Class I and II airports, besides their independent role of serving intra-republic and intra-oblast communication.

Class I and II airlines are a constant means of transportation, providing rapid communication, and therefore are developing successfully along lines parallel with surface transportation. In contrast to this, the duration of some Class III and IV airlines depends on the fluctuations in the transportation service of the region. The construction of a railroad or highway can lead to pioneer and local airlines losing their importance in whole or in part.

Class III airlines will, as a rule, be short. The conditions under which they can be put to efficient use are described in Chapter II, where the economic effectiveness of passenger hauls across short distances in regions served by railroad and bus transportation is analyzed.

The major characteristic of pioneer airlines is not that of rapid transport, but rather the only means of transport. Therefore, Class III airlines, besides carrying passengers and mail, can, under certain circumstances described in Chapter II, also carry considerable freight hauls.

Service requirements of Class III airlines can be limited to year-round, and sometimes seasonal service, primarily in the daytime. An exception can be made for airlines in northern regions, where winter daylight is so short that it is not sufficient for the completion of a flight, making airport lighting necessary.

Requirements of Class IV airlines, which will carry passengers and mail over relatively short distances, can also be limited primarily to daytime service. Maintaining all-year traffic on republic and local airlines can be achieved without the construction of runways with artificial covering at the airports. During spring and fall slush, when the use of planes becomes impossible, the minimal necessary air communication can be kept up through the use of helicopters.

Those airports which can land and dispatch planes of various weights must be relegated to the highest airport classification, judged by equipment, meeting the requirements of the heaviest planes.

The expediency of combining both large jet and small plane service at one airport requires special investigation. In the USSR, and abroad, there is a tendency toward specialization and the designation of some airports for multi-passenger jets, and others for local airline service. This is dictated by considerations of operation, for with a great deal of traffic serious problems arise with landing and dispatching planes of different classes.

Several places -- Moscow, Kiev, and Novosibirsk, for example -- already have specialized airports according to the technical servicing of various types of airplanes. With several airports available, the matter of establishing junctions arises as a problem in a network using different classes of airlines. Usually, for reasons of flight safety, airports are located at a distance of several dozen kilometers from each other, often on different sides of town. A well-running automobile transit system will be needed to complete communication between airports; and various capacity helicopters would be most efficient for rapidly transporting passengers and express mail and freight hauls.

4. DISTRIBUTION OF AIRPORTS AND AN AIR COMMUNICATIONS NETWORK

The distribution of airports and main airlines serving passenger travel between economic regions of the USSR is shown in Fig. 5.

The number of Class I airports in economic regions is determined by a series of economic and geographic factors, among them, size and configuration of the area, size and distribution of population, and the region's transportation services. In selecting airport sites one must not only consider the point's population size, but its potential for becoming a center -- drawing passengers from adjacent oblasts. The following 29 cites are chosen for Class I airports in various economic regions of the USSR. They include those points where airports of a corresponding technical level have already been constructed, or are in the process of being built:

Northwest - Leningrad
Industrial Center - Moscow
Volga-Viatskii region - Gor'kii
West - Minsk, Riga
South - Kiev, Odessa, Khar'kov, Simferopol'
North Caucasus - Rostov-on-the-Don
Trans-Caucasus - Baku, Tbilisi
Along the Volga - Kuibyshev, Stalingrad
Ural - Sverdlovsk, Cheliabinsk
Kazakhstan - Alma-Ata, Karaganda

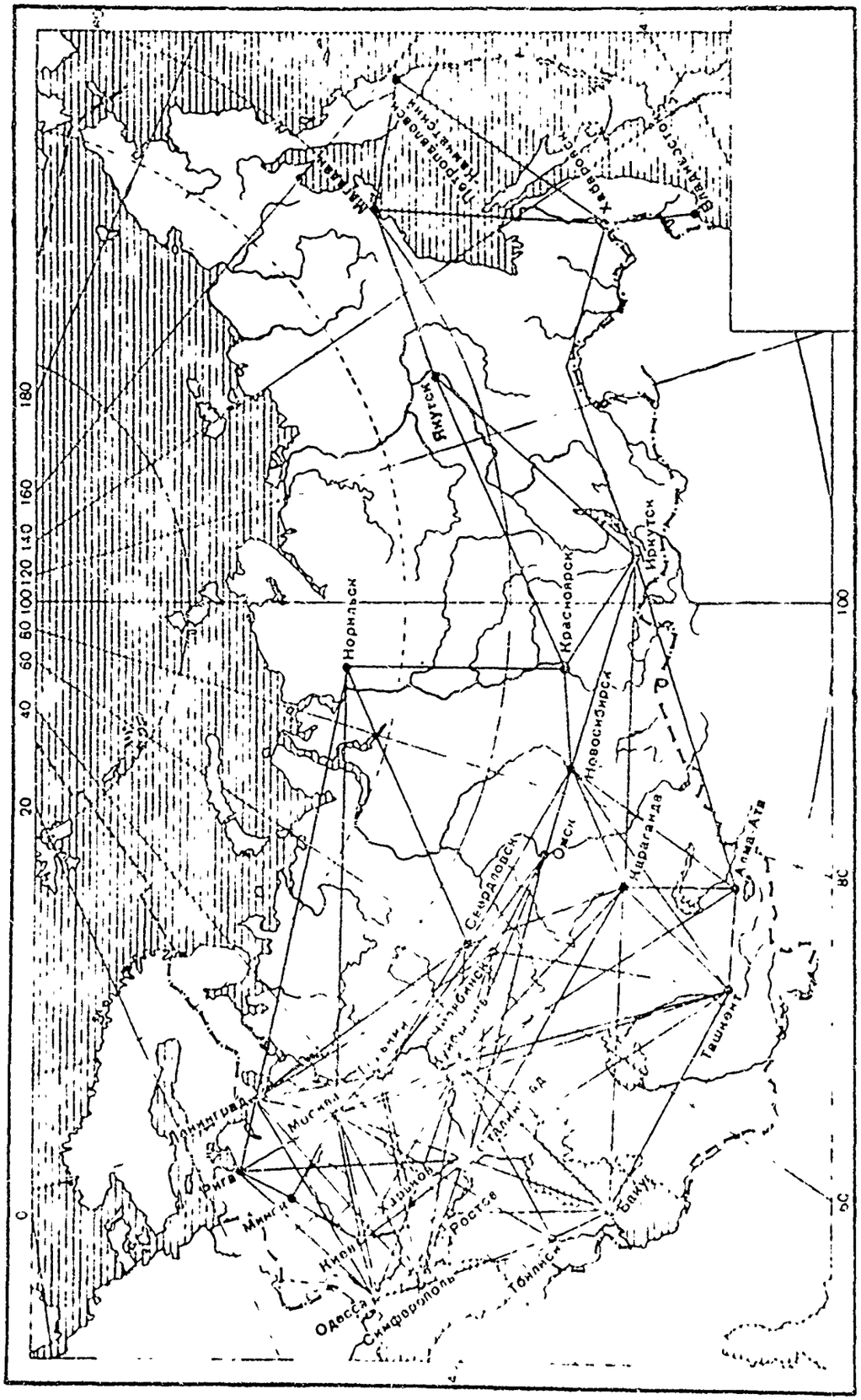

Fig.5—Scheme of USSR express routes

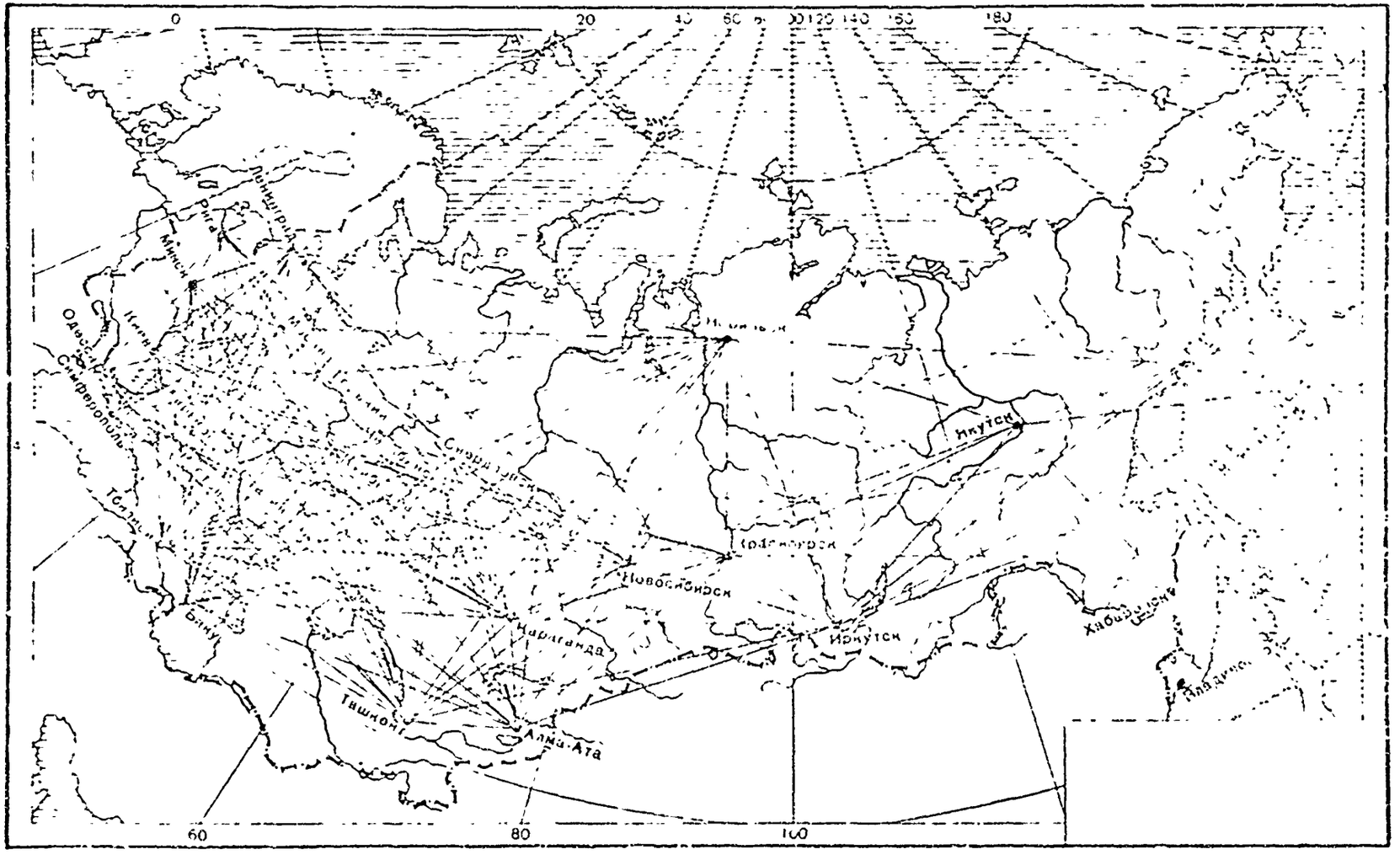

Fig.6—Scheme of possible Class I airlines in the USSR

Central Asia - Tashkent
Western Siberia - Novosibirsk, Omsk
Eastern Siberia - Irkutsk, Krasnoiarsk, Noril'sk, Yakutsk
Far East - Vladivostok, Khabarovsk, Petropavlovsk in Kamchatka, Magadan.

Of course, this list is only a model. It is possible that it will have to be corrected in the future towards a partial change or increase in number of points. The outlined network of airports will allow for the exchange of passengers and mail between the main economic regions of the USSR in any combination along the shortest route, as well as transit communication across the Soviet Union.

Besides the main routes which now connect, through Moscow, the European oblasts of the USSR with its Asiatic part, the creation of parallel main lines is foreseen, connecting the South, Northern Caucasus and Transcaucasus with Ural, Siberia, Kazakhstan and Central Asia along the shortest routes, and avoiding the most loaded airports.

A maximum distance of 2,000 - 2,500 kms is maintained between Class I airports by airlines situated in Siberia and the Far East. But such a distance is only about 50-70 percent of the practical flight distance of such airplanes as the Tu-114 or the Tu-104B with a full commercial load.

The express routes shown in Fig. 5 are far from encompassing all possible lines of travel for the types of planes named. The number of such lines is great, because with a practical distance of 3,000-4,000 kms, non-stop flights can be completed in any combination, not just between all airports of the nation's European part, but also between them and airports of the USSR's Asiatic part, even up to Novosibirsk and Alma-Ata. It does not make sense to create such an excessively dense air communications network on multi-passenger jets.

However, this map well illustrates those unlimited possibilities which will be available to air transport in creating a rational system of air communication, serving all the needs of the national economy

and population, and connecting by the shortest routes the centers of USSR economic regions. Although the general outline of the network of express lines will, in essence, correspond to the existing network of major all-Union airlines, a number of new destinations will also be developed. Among them should be included those connecting the South and the North Caucasus on one side, with Central Asia, Kazakhstan, Western Siberia and Eastern Siberia on the other; the Transcaucasus with Kazakhstan and Siberia; the North-West with Western Siberia; and several others. Passenger travel between these regions can be accomplished along the following routes: Kiev (Khar'kov) - Tashkent; Odessa (Khar'kov) - Stalingrad - Karaganda (Alma-Ata); Khar'kov - Novosibirsk; Rostov - Tashkent; Rostov - Karaganda - Novosibirsk; Leningrad - Novosibirsk.

The list of Class II airports is longer than that of Class I. It includes, in conformity with the model classification scheme for airlines, the following cities of economic and administration significance:

North-West - Murmansk
European North - Arkhangel'sk
Industrial Center - Yaroslavl'
Black-Earth Center - Voronezh, Briansk, Kursk
Volga-Viatsk region - Kirov
West - Vil'nius, Tallin, Kaliningrad, Kaunas
South - Stalino, Dnepropetrovsk, L'vov, Krivoi Rog, Zhdanov, Nikolaev, Kishinev, Lugansk
North Caucasus - Krasnodar, Mineral Waters, Groznyi, Adler (Sochi)
Transcaucasus - Erevan', Sukhumi
Along the Volga - Kazan', Saratov, Astrakhan', Ul'ianovsk, Penza
Ural - Perm', Nizhnii Tagil, Magnitogorsk, Izhevsk, Orenburg, Ufa
Kazakhstan - Semipalatinsk, Kustanai
Central Asia - Stalinabad, Frunze, Samarkand, Ashkhabad
Western Siberia - Stalinsk, Barnaul, Kemerovo, Tomsk
Eastern Siberia - Chita
Far East - Komsomol'sk-on-the-Amur, South Sakhalinsk

The above list includes 49 points. Of the number of large cities with a population over 200,000, this list does not include several cities which are located near another large city, where an airport is being planned. Among these are: Zaporozh'e -- within 65 kms of Dnepropetrovsk; Makeevka and Gorlovka, 20-50 kms from Stalino; Prokop'evsk, 25 kms from Stalinsk; and Taganrog, 80 kms from Rostov-on-the-Don.

It is obvious that a well-established suburban transit system between neighboring cities (railroad, bus or helicopter) will make it possible for them to be served by one main line airport, without building another one nearby, and limiting it to, as Saporozh'e has done, a Class III airport.

Class II airports are not planned in Tula, Riazan', Ivanov and Kalinin, which are situated within 200-250 kms of Moscow, the major connection point of passengers with the cities named. We may suppose that the major part of passenger hauls for these cities will be by surface transport, and the long-distance connections through the Moscow airport. Class III airports, therefore, are being planned for these points.

Among cities with a population under 200,000, Class II airports are being planned in the following cities (besides republic capitals) -- Stalinabad, Frunze, Kishinev and Ashkhabad -- and such fast-growing peripheral cities as Kaliningrad, Murmansk, Kustanai, Samarkand, Chita, Komsomol'sk-on-the-Amur and South Sakhalinsk, as well as the most important resorts of the Soviet Union -- Mineral Waters, Adler (Sochi) and Sukhumi -- with large and varied passenger communication systems. In addition to the above named places, provisions should also be made for the construction of several airports in outlying roadless regions, where large industrial centers will be created.

All Class I airports will, naturally, be used by Class II airplanes as well. Therefore, we can consider that the network of airlines will be based on no less than 100 airports. With the use of planes with capabilities for non-stop flight distances of 2,000 kms, it will be possible to organize a large number of various routes all over the territory of the USSR.

In the airline classification model, Class III airports are located in centers of autonomous republics and oblasts, as well as in other cities with a population over 50,000. There will be about 130-140 such points, and if we count remote industrial centers, their number can grow to 150-170. Their exhaustive list is not given, because intensive economic research and analysis of the concrete conditions of communication with corresponding passenger and freight points must precede the decision about the distribution of these airports.

The total number of Class IV airports, which, principally, must connect oblast centers with agricultural regions, can roughly be determined by basing the calculation on the latter's distance from the oblast city (see Table 15).

Of the total number of regional centers located up to 100 kms from the oblast city, around 85 percent are satisfactorily served by surface transportation means.

Table 15

THE DISTANCE OF AGRICULTURAL REGIONAL CENTERS FROM OBLAST CITIES

Distance (kms)	Number of Regional Centers	Percent of Total
Up to 100	1,537	38.6
101 - 200	1,247	31.4
201 - 300	631	15.9
Over 300	561	14.1
TOTAL	3,976	100.0

Source: Administrativno-territorial'noe delenie soiuznykh respublik na 1 ianvaria 1958 g. (Administrative-Territorial Distribution of Soviet Republics on 1 January, 1958) Moscow. "Izvestiia Sovetov deputatov trudiashchikhsia SSSR" Publishers, 1958.

Of regional centers located at a distance of 101 to 200 kms, approximately 40 percent are satisfactorily served by railroad and automobile transportation. When the distance becomes 201 to 300 kms, air

communication is required by 90 percent of the regional centers, and by 100 percent when the distance is over 300 kms. So, the total number of agricultural regional centers requiring air communication is approximately 2,000-2,100. At present local airlines serve about 1,600 regional centers. Future plans should, therefore, be made for enlarging the network of local airlines.

The distribution of intra-oblast airlines will be determined to a great extent by the development of surface means of communication, primarily auto transport. The network of local airlines, which, besides providing intra-oblast communication, will also serve as a "spur track" for Class I, II, and III airlines, can be rather complex. It will provide radial air routes connecting oblast cities with regional centers, and in some instances, when the commercial haul is not large enough, it may be efficient to organize ring routes, with one route serving several populated areas. A combination of radial, ring, and half-ring airlines is also possible, especially in oblasts and autonomous republics large in territory. Examples of such are the Yakutsk ASSR, Kamchatka and Magadansk oblasts, and the Krasnoiarsk krai. In order to serve populated points spread out over a large territory, it may be necessary to set up additional local airlines junctions, which, in turn, will be connected by air with oblast centers.

The distribution of airports of various classes, necessary for the complex development of air communication in the Soviet Union, is characterized by the following data:

Class of Airport	Percent of Total
I	1.5
II	2.8
III	7.2
IV	88.5
TOTAL	100.0

According to plan, the territory of the USSR will be served by Class I and II airports with a distribution of one per every 225,000 km^2.

One airport of republic and local airlines will serve a territory of 10,000 km^2.

Obviously, the whole country cannot have equal service. The "density of service" must be greatest in the densely populated European part, and least in Siberia, where the number of populated points is not great. In the South one main line airport will be situated approximately every 50,000 km^2; in Western Siberia -- every 400,000 km^2; in the Far East -- 500,000 km^2. An even lesser "service density" will be present in Eastern Siberia -- one major line airport per 1,450,000 km^2. However, the "service density" of airports per persons of the population will be considerably larger in the outlying areas than in the western regions of the Soviet Union. In Siberia and in the Far East there is one major line airport per 1.3 million people; in the Ukraine there are 3.7 million people per airport. In Central Asia there is one main line airport per 2.5 million people, and in Kazakhstan -- per 2.1 million.

In the present seven years, in accordance with the decision of the XXI Congress of the CPSU, it is planned to reconstruct and build over 90 major airports, and to widen the network of airports on local airlines. Fulfillment of this program will considerably raise the technical level of airlines.

Speaking of the perspectives of air communication development, we must mention hydro-aviation. The use of hydroplanes in the Soviet Union is very limited. This is partly because the roadless regions of Siberia and the Far East have a long and harsh winter, and the use of hydroplanes is impossible for a large part of the year. In the winter period, therefore, when air transport becomes especially necessary for these regions, communication by regular planes as well would be needed. This, however, would bring with it an unjustified increase in capital investments for surface equipment of the airlines.

The development of air lines of communication, corresponding to the named classification scheme, can therefore be characterized in the following manner. The base points of major USSR air routes are Class I airports, located in large economic centers of the country. This is

the backbone of air communication lines, providing express communication between all major economic regions of the USSR, transit communication across the Soviet Union, and international passenger travel. Technical equipment of Class I airports must correspond to the requirements of the largest jets, and in perspective -- also of supersonic planes.

This backbone of routes is overlayed and supplemented to a considerable degree by a network of main lines based on Class I and II airlines.

The airlines of the first two classes together must satisfactorily meet the needs of the population for fast, long-distance travel, taking upon themselves the major portion of the country's passenger travel for distances over 1,000 kms, and to a considerable extent replacing fast railroad passenger transport. These same airlines will be able to effectively serve passenger and mail hauls between all large cities of the nation within the range of 500-600 to 1,000 kms.

The wide network of republic and oblast airlines must serve as the "spur track" feeding the major airlines, while simultaneously providing intra-regional or local passenger and mail hauls. In certain circumstances local airlines may serve as the pioneer transport to areas where natural resources are being tapped, and in meeting the needs of the first settlements for freight hauls of several tens of thousands of tons annually.

5. THE DEVELOPMENT OF THE TECHNICAL MEANS OF AIR TRANSPORT

The decisive condition for air transport development is an all-round raising of its technical level. Control figures for the development of the USSR national economy for 1959-1965, confirmed by the XXI Congress of the CPSU, foresee a fundamental technical reconstruction of air transport. The most important link of this reconstruction is the use of new types of planes and the widening of the network of airports, raising, at the same time, their technical level.

At present, the types of transport planes to be utilized have been determined to a considerable extent. Among them are those planes with

gas turbine engines. The turbojet Tu-104 and the turboprops Tu-114, Il-18 and An-10, respective of their amortization periods, will be utilized during the coming eight-ten years, i.e., up to 1968-1970.

In addition to these planes and others already in use, passenger planes with gas turbine engines have been created: the turbojet Tu-124, seating 40 passengers, with a flight speed of 800-850 kms/hour and a flight distance of 1,500 kms; and the turboprop An-24, seating 45 passengers, with a flight speed of about 500 kms/hour. These planes will be the intervening ones between the large planes of the Tu-104 or Il-18 types, and the dual-engine piston-type Il-14, Il-12 and Li-2. The Tu-124 and the An-24 will gradually replace the piston-engine planes and will become the major types on republic airlines. In commercial freight capacity they are close to the Dutch turboprop Fokker Friendship with 32-40 seats, a flight speed of 430 kms/hour and a flight distance of 1,300 kms.

With the creation of the Tu-124 and An-24, air transport will have planes of varying passenger capacity: 3, 6, 10, 24, 40-50, 75-100, 170-220 seats. These types of planes will apparently be the major ones determining the technical-economic level of all air transport in the nearest decade (1960-1970). This same period will, undoubtedly, see the creation of new types of airplanes.

For the major air routes of the Soviet Union and for international communications with distant countries it would be desirable to create supersonic transport passenger planes with speeds of 2,000-2,500 kms/hour. Trends in the development of airplane construction allow one to suppose that technical progress will make the use of supersonic airplanes economically efficient for very urgent and distant hauls. However, on medium-range airlines the economy of time which may be achieved with the use of supersonic planes as compared to planes flying at speeds of 600-800 kms/hour, will be so small that the increased transport costs could not be justified.

Also deserving of special attention is the problem of coordinating passenger and freight loads on transport planes. As can be seen from Table 16, this coordination varies considerably on different types of

Table 16

CORRELATION OF PASSENGER AND FREIGHT LOADS ON TRANSPORT PLANES

Type of Plane	Passenger Load: Number of Seats in Tourist Class	Passenger Load: Total Passenger Weight* (tons)	Freight Load, Total Weight* (tons)	Maximum Total Load of Plane (tons)	Share of Weight Load in percent: Passenger	Share of Weight Load in percent: Freight
USSR						
Tu-104B	100	9.0	3.0	12.0	75.0	25.0
Tu-114	170	15.3	14.7	30.0	51.0	49.0
Il-18	100	9.0	5.0	14.0	64.3	35.7
An-10	100	9.0	4.0	13.0	69.3	30.7
U.S.						
Boeing 707-420	162	14.6	4.5	19.1	76.5	23.5
Douglas DC-8	171	15.4	1.8	17.2	89.5	10.5
Lockheed Electra	85	7.7	2.1	9.8	78.6	21.4
Convair 880	108	9.7	2.2	11.9	87.5	18.5
England						
De Haviland Comet 4B	99	8.9	1.1	10.0	89.0	11.0
Bristol Britannia 300	133	12.0	1.6	13.6	88.3	11.7
Vickers Viscount 810	52	4.7	1.1	5.8	81.1	18.9
France						
Caravelle	80**	7.2	1.8	9.0	80.0	20.0

*Taking the average weight of one passenger with baggage at 90 kg.

**In Class I.

airplanes, both national and foreign. The predominant majority of foreign airplanes is clearly passenger specialized. The largest passenger share in the total commercial load is observed in British-built airplanes. The share of passenger load on U.S. transport planes is between 76.5 and 89.5 percent.

A large share of passenger load is foreseen in Soviet planes designed by A. N. Tupolev -- the Tu-104B. But, this cannot be said about the An-10 and Il-18.* The share of passenger load on these airplanes is much smaller than on all other planes of a similar class. About one-third of the total commercial load on the types of planes named is devoted to freight, and absolute volumes of the freight load reach considerable proportions.

In the next few years the general structure of air transport hauls will change substantially. The share of total passenger hauls throughout the whole network of USSR airlines will reach 70 percent, and in the future -- 80 percent, i.e., it will be higher than the correlation between passenger and freight loads planned for the An-10 and Il-18. But in this general structure an important place is occupied by freight hauls on freight planes in roadless regions. The majority of main air routes where the types of airplanes named above are being used, already shows a high percentage of passenger hauls. Therefore there is reason to suppose that serious problems will arise in attracting air-transportable freight to fill up the freight compartments of passenger airplanes. This will lead to the incomplete utilization of their commercial capacity and a corresponding increase in the total cost of hauls.

It should be noted that with an increase in the total freight capacity of transport planes the problem of their specialization in passenger and freight hauls becomes ever more important. The maximum possible freight load of an An-2, carrying ten passengers, does not exceed 0.2 ton; an Li-2 21-seater -- 0.5 ton; and the An-10 and Il-18, as noted above, 4-5 tons with a capacity passenger load. If as in the past the freight compartments of planes were filled to a considerable degree

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*(Ed. note: designed by O. K. Antonov and S. V. Ilyushin, respectively.)

by mail, then in the near future the mail load will occupy an insignificant part. Besides, heavy passenger flows are not always accompanied by flows of express and other air-transportable freight. Consequently, a greater specialization of transport planes, according to types of hauls, is necessary in the future. Besides passenger planes it is necessary to have special freight planes, equipped to transport relatively large sized freight. The freight planes will require extra strong floors because of greater load density and pressure per unit of space in transporting heavy freight. The planes should be equipped with devices for mechanized loading, unloading, and securing of the freight. Obviously, freight planes do not need the special equipment necessary for transporting passengers.*

It is efficient to use special freight planes not just in roadless regions, but also on many routes parallel to railroads, for transporting various freights, including products which spoil rapidly.

The necessity of specializing planes according to types of hauls will grow with an increase in the general volume of air transport work, for it is best to divide freight from passenger hauls for utility considerations as well. This facilitates the process of loading and unloading at airports, especially during short stops at intermediate terminals on the air route.

Another important problem is the need for an airplane to haul passengers short distances (400-500 kms). Up to the present time the major tendency in airplane construction has been to build an airplane with a maximum flight distance, in order to insure non-stop flights along the longest routes. As a result, transport planes have been created with a practical distance of 6,000-8,000 kms (Tu-114, Boeing 707, Douglas DC-8, Bristol Britannia), capable of non-stop transcontinental flights. Planes for short- and medium-range communication have also been constructed. However, aircraft designers have so far not devoted adequate attention to the multi-passenger plane for short

*The An-10s will be produced in three types: passenger, freight, and freight-passenger. Grazhdanskaia aviatsiia (Civil Aviation), No. 2, 1959, p. 28.

routes. Meantime, there is reason to suppose that air transport can become economically efficient for short-distance passenger transport.

The major advantages of using airplanes for short distances are:

1. a greater commercial load because of a decrease in fuel supply carried, fewer crew members, eliminating the buffet and other equipment necessary for long-distance flights;

2. lower expenditures for flight crew salaries because of the reduction in personnel (flights without an engineer, radio operator, and stewards);

3. minimum expenditures for passenger services in flight;

4. the possibility of greater returns from hauls because of the differentiation in fares according to distance. The profitable rate for one passenger/km, when hauling the air passenger for a distance up to 200 kms is 30 kopeks, for 400 kms -- 27 kopeks, for 1,000 kms -- 23 kopeks, and for 5,000 kms -- only 18 kopeks.

In this manner, even if the prime cost of a 400-km haul will be 1.5 times higher than the prime cost of a 5,000-km haul, there will be no difference in their profit margin. This condition is very significant, because air transport, operating as a khozrashchet* enterprise, must consider the relation between income and expenditures, not just the prime cost of the haul.

The problem then, consists in building an airplane for short distances (an "air bus") whose level of prime cost of hauls would be considerably lower than that of the An-2, now in use on local airlines.

There is a correlating dependence (function) between the size of the airplane and the prime cost of hauls. The economic advantages of large airplanes are tied to the following factors. With an increase in the size of the plane, its aerodynamic qualities, as a rule, also become higher -- there is the possibility of using more powerful engines, which have better economic indicators of fuel use and weight

*Financially independent, meeting costs from profits.

per unit of power. The weight of the structure constitutes a smaller part in the total flight weight of the plane, and therefore the useful load share is higher on larger planes.

Until the present time an increase in the size of airplanes was usually accompanied by an increase in flight distance, which required that a considerable part of the useful load capacity be utilized for fuel storage. With the design of short-distance planes the required supplies of fuel will be drastically reduced, thereby increasing the commercial load's share. This is the most important basis for bettering the plane's economic indicators.

The problem of designing a plane for short distances has been discussed abroad for the past few years, especially in England.* Air transport companies are working on the requirements for planes of this type. It is necessary to examine this problem in detail for the network of USSR airlines too.

More attention should be devoted to the design and construction of planes with shorter landings and takeoffss, i.e., short takeoff planes (SKV)** and vertical takeoff planes (SVV). With such transport planes it will be possible to radically shorten the length of concrete runways, and thereby the area necessary for constructing an airport. This can then be brought considerably closer to populated points, and access time can be reduced. At the same time capital investments in the construction of airports will be reduced.

In pointing out these problems, it should be noted that the successes achieved in airplane construction are not accompanied by corresponding development of other components of air transport. The great advantages of speed in air travel, as compared to surface travel, are lost to a considerable degree because too little attention is devoted to lessening the access time (time needed to arrive at the airport).

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*P. Brooks, Problem of Short-Haul Air Transport, Royal Aeronautical Society, June 1952. S. Wheatcroft, The Economics of European Air Transport, Manchester, 1956.

**(Ed. note: Russian initials for "short takeoff plane.")

For instance, the flight from Moscow to Sverdlovsk, a distance of 1,500 kms, takes only two hours on a Tu-104. Just as much time is needed for the trip from Moscow to the Vnukovo airport, and from the Sverdlovsk airport to the center of town. In this manner, access time takes too big a share of the total travel time.

An introduction, on the same route, of a supersonic plane with a speed of 1,500 kms/hour, i.e., twice the speed of the Tu-104, will only lead to lessening the total time by one-fourth -- from four to three hours. A radical solution of this contradiction will probably require special helicopter communication between the center of town and the airport, because out-of-town lines of the Metro and surface electric railroads can only be constructed in the largest cities, with heavy passenger traffic. Helicopters are much less economical than airplanes, and their utility sphere is rather limited. However, they can be used effectively for short distances, connecting the city and the airport. Within distances of 10-15 kms, even with a price cost of one ruble per passenger-km, the total expenditure for a helicopter flight from the city to the airport will be an insignificant part of a passenger's air fare.

Therefore, there is reason to suppose that the construction of special passenger helicopters for suburban communication is a necessary and urgent thing.

Chapter IV

PRINCIPLES OF MEASURING AIR TRANSPORT'S ECONOMIC EFFECTIVENESS

In evaluating the economic effectiveness of air transport in comparison to other forms of transport -- railroad and bus -- it is important first to take into account the following important indicators: prime cost of hauls, capital investment needs, and speed of hauls.

Preliminary accounts lead us to conclude that in the future the prime cost of passenger hauls will go down on all types of transport, although not equally. The largest decrease in prime cost of hauls is expected in air transport because of the introduction of large-capacity, fast planes with high economic indicators. The rapid process of perfecting airplane construction and the utilization of gas turbine engines will decrease the direct (flight) costs by no less than two times. The most important factor in lowering direct costs is lengthening the periods between repair and the airplane depreciation periods, especially that of the engines.

The procedure of writing off amortization on air transport is different from other forms of transport. In railroad and water transport, deductions into the amortization fund are determined by definite norms (percentages) and made from the average annual cost of all capital, including the rolling stock of the railroads or the transportation fleet. The additions to amortization for railroads and water transport take place during the exploitation of fixed funds (locomotives, cars, ships), and during the times of repair or standing idle, independent of their duration.

For air transport, writing off amortization takes place for each hour of operating (flying) the plane and engine, including writing off renovation and capital repair. In connection with this the amounts being written off depend not only on the cost of the planes and engines, but equally on the periods of amortization and those between repairs. At the present time, when new gas turbine airplanes are still in the first stage of their production and utilization, the periods of service

of the airframe and especially the engines are small. Therefore, the amortization deductions for every hour of their operation are quite large: for some types of planes they are 40-50 percent of all direct costs. In this, the larger part of the amortization deductions (70-75 percent) are expenditures for the renovation and capital repairs of engines.

From the above it is perfectly clear how very important lengthening the service periods of aircraft engines is for the air transport economy. Great reserves for lowering the prime cost of air hauls are hidden here. The times between overhaul of some foreign types of gas turbine engines already are quite long, and are gradually approaching the service periods acquired long ago by piston engines. For instance, the Rolls-Royce Avon RA.29 turbojet, installed on the Comet IV, has a time between overhaul period of 2,000 hours.* The time between overhaul period of the turboprop engines installed on the Lockheed Electra is 1,000-1,200 hours. Supposedly, these guaranteed periods will be increased by some 30-50 percent in the near future. A two-fold increase in the service periods of aircraft engines will lead to a decrease in direct costs per ton-km of 15-20 percent in comparison to the existing level. And this can be viewed as only the beginning.

An important factor in lowering the prime cost of hauls is an economically rational distribution of the air fleet, especially in outlying regions, where the correct choice of plane must be determined with considerations of load composition, length of flight without refueling, and other factors. For regions situated far from the railroads, a plane with a minimum fuel consumption would be the most economical. The reason for this is the high cost of fuel and lubricating materials in outlying regions because of the high expense of bringing aircraft fuel to the airports of these regions.

The possibility of considerably increasing the number of passenger seats in a plane by eliminating many of the unnecessary items for passenger service is also a reserve for lowering the prime cost of hauls.

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*Airlift, July 1960, p. 16.

Only the necessary comforts should exist in planes, because the predominant number of air passengers travel over distances covered by the plane in a matter of several hours. Ninety percent of all passengers travel for distances up to 2,500 kms, and such a flight takes 3-4 hours in a jet or turboprop plane. Is it necessary to supply the passengers with hot food, equip the plane with a kitchen with electric stove and refrigerator facilities, and have additional personnel on board -- cooks and stewards -- for a flight of this length, not to mention shorter ones? Dining cars are only included on long-distance trains, with no less than 24 hours of travel between the end points. Also, passengers on inter-city buses with 250-300 km routes, that is, approximately five hours, are not fed. On 2,500-3,000 km flights there is no reason to create a higher level of comfort and service than exists on trains or inter-city buses. Such service should be reserved for passengers traveling over 3,000 kms.

Equipment for food service should be planned for a relatively small number of planes -- those intended for especially long trips. In all other planes the number of passenger seats should be increased because of the removal of buffet equipment and the reduction of flight personnel. This will make for a corresponding decrease in the prime cost of hauls, and thereby lower ticket prices.

At the same time let us note that foreign airlines have, during the past few years, introduced passenger hauls on a second, so-called "tourist" class. Smaller seats are used for this class, thereby allowing for a 25-30 percent increase in the plane's passenger capacity. At the beginning of 1958 a third, or "economy" class was introduced, with still lower levels of comfort, and no food, which allowed for a further increase in the number of passenger seats. So, in the Boeing 707 jet, first class has 122 seats, tourist class, 147 seats, or "economy," 189 seats.

Air fares are established in accordance with the various levels of comfort and service. And experience has shown that passengers prefer the cheaper, economy class for transatlantic flights. Of the total passengers traveling in 1959, 73.8 percent traveled economy class, 4.7

percent traveled tourist, and 21.5 percent traveled first class. The highest commercial load -- 68 percent -- was in the economy class; it was 63 percent in first class.* The close connection between air fares and number of people flying is well known. Lower fares will undoubtedly lead to an increased number of passengers, which will have a favorable effect on the profit margin of air communication.

These are some of the ways of lowering the direct operating costs of air transport. The possibility of lowering the share of airport expenditures should also be considered.

The density of traffic on the airlines is still not very great. Therefore, the share of airport costs in the total prime cost of hauls is unjustifiably high -- around 30 percent. Because airport costs grow at a considerably slower rate than the volume of hauls, their share in the prime cost should gradually decrease with an increase in passenger and freight turnover. This will lead to the general decrease in the prime cost of air hauls.

There is reason to suppose that in the next 5-7 years the prime cost of a passenger-kilometer on various forms of transport (with 60-65 percent of the passenger seats filled) can be presented as follows (in kopeks):

A. Fast train (average along the network):

   Soft car -- 12
   Hard car, compartment -- 9
   Reserved seats car -- 6

B. Bus transport, inter city -- 9

C. Air transport, excluding outlying regions:

   Main line turbojet -- 12-13
   Main line turboprop -- 10-12

In comparing the prime costs of hauls by air and surface transport, it should be kept in mind that the basic costs of hauls must be determined with a consideration for the distance to be traveled by passengers

*Airlift, May 1960, p. 64.

or freight. As has been noted earlier, railroads and highways are, on the average, 25 percent longer than parallel air lines, and therefore the volume of transportation work in passenger-kilometers on surface roads will be 125 percent of the passenger-km count on the same haul by air. Therefore, when comparing the economy of hauls by air and surface means it is necessary to include the corresponding correctives, in conformity with the basic conditions, among the prime cost indicators of a unit of transportation production, that is -- passenger-kms.

In comparing the various types of transport as a whole, one can, with certain reservations, admit that the prime cost of one passenger-km on air transport should be multiplied by a coefficient of approximately 0.8, and the result then compared with the prime cost of one passenger-km on railroads or inter-city buses. With this corrective, we can say that the costs of passenger hauls on turboprop planes will be close to those in hard compartment railroad cars and buses; and on turbojets they will be lower than in soft railroad cars, but approximately 10 percent higher than in the hard cars.* All this gives reason to suppose that air transport's prime cost will reach that of surface forms of transport and we will be able to view air transport as a means of mass passenger communication.

Now let us look at the second indicator -- capital investment. The capital investments necessary in developing the hauling capacity of each form of transport are made up of investments in surface installations and the moving fleet.

The major part of surface installation investments in land transport is made up of expenditures for the construction of the road (usually calculated per kilometer of railroad or highway). Using this indicator, it is possible to compare the capital expenditures for different forms of surface transport.

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*Modifications on turbojets will make for considerable increases in their economy and will bring their prime cost of hauls close to the turboprops' indicators. For example, the Tu-104B carries 100 passengers, as against 70 on the Tu-104A. With the hourly operation costs unchanged, this will make it possible to lower the prime cost of hauls by approximately 30 percent.

But this method cannot be used in comparing capital investments for air and surface transport. Airports for air communication in one direction are now only being built in outlying roadless regions. The construction of a new main line airport at some point usually makes it possible to connect that point by air with dozens of airports in various regions. It follows then, that expenditures for airport construction should not be assigned to just one direction, parallel to the surface route, but to the whole widening network of air communication. One should also keep in mind that airports serve not just transport, but other forms of aviation as well. Therefore, expenditures for airport construction are not simply investments in air communication, but also in agricultural, forest, medical and other aviation.

Special investigation is necessary to compare the capital investment requirements for surface installations in air transport with railroad or bus transport. Therefore we shall have to limit ourselves to comparisons of capital investments in the moving fleet, calculated per unit of haul.

Since air transport is primarily passenger transport, and capital investments are determined by passenger moving fleet, we will consider a unit of haul as one billion passenger-seat-kms.

In railroad transport capital investments are determined by the standard of a long-distance train with 532 passenger seats, 14 compartment cars, each with 38 seats, one baggage car, and one dining car. The number of locomotives per passenger train is usually 1.9 (accounting for those in reserve and repair). The train's transport capacity -- calculated from the average daily distance covered by a car as equal to 550 kms -- is 107 million passenger-seat-kms a year.* The capital investments for one billion passenger-seat-kms are 54 million rubles, in conformity with the current prices of railroad cars and locomotives.

Capital investments for bus transport are determined on the basis of a 32-seat, inter-city ZIL-127 bus, which, with an average daily run of 250 kms, has a transport capacity of 2.9 million passenger-seat-kms

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*E. V. Mikhal'tsev, Sebestoimost' zheleznodorozhnykh perevozok (Prime Cost of Railroad Hauls), Moscow, Tranzheldorizdat, 1957, p. 153.

a year. With the cost of the bus at 220,000 rubles, the capital investment for one billion passenger-seat-kms is 78 million rubles.

Because of the lack of data in print on the costs of airplanes, the author calculates the capital investments in air transport according to the prices of foreign turboprops and turbojets, approximating Soviet planes in class and type. These capital investments are calculated with a consideration for the difference in intensity of utilization, within the range of 1,000-3,000 hours of annual flight time for a written-off plane. Calculations of the capital investments in air transport's moving fleet are based on the price of the plane together with the engines. Funds assigned for the acquisition of new engines to replace the amortized ones are not included in the sum of capital investments. The reason for this is that the service periods of aircraft engines are relatively small (1,000-1,500 hours). With a plane's average annual flying time of 2,000-3,000 hours, the engines are wholly amortized in less than a year, and renovation items written off accumulate in quantities large enough to justify the acquisition of new engines. Therefore it is hardly correct to view an engine as an item of long-time use, and to relegate it to fixed funds, as is being done now. From an economic point of view, the expenses incurred in acquiring new engines to replace the amortized ones are not capital investments. The latter should only include the initial acquisition expenditures for the plane and its engines.

From Fig. 7 it is evident that capital investments in turboprops, with an annual flight time of around 1,700 hours, become equal to capital investments in railroad rolling stock. For turbojets this is the case at 3,000 hours. In comparison with bus transport, capital investments in turboprops become equal at 1,250 hours annual flying time, and in turbojets at 2,600 hours.

Therefore, the view of the high capital investment needs of air transport is incorrect, at least concerning passenger hauls. With an intensity of plane utilization at the limits already attained,* capital

*Average flying time per plane written off in the United States is around 2,500 hours annually, and 1,800 hours on planes of Western European airlines. American Aviation, May 20, 1957.

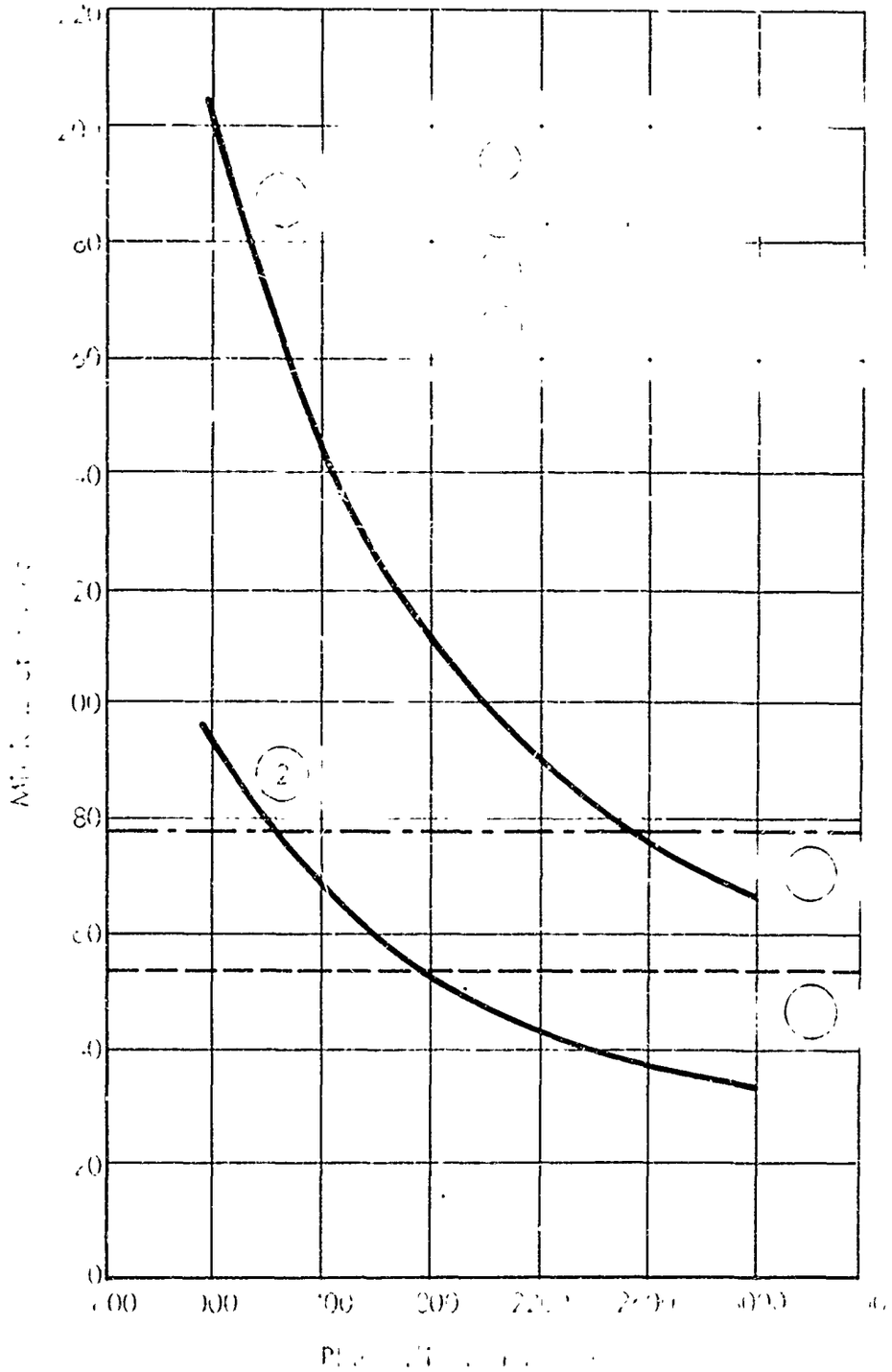

Fig. 7 - Capital investments per one million passenger-miles. Comparison of costs in comparable railroads and buses

investments in air transport (using turboprops) are lower than those for railroads and buses.

Investigations on transport economy usually relegate the speed of hauls to the qualitative indices, together with comfort, regularity and safety. The economic effectiveness of faster freight hauls is usually expressed in a faster turnover of working capital and a decreased store of products in flight. This effectiveness is not equal for various freights and different economic conditions. The economic effect from faster passenger hauls is expressed in the time saved.

Bourgeois economists value speed exclusively as a means of providing greater competition in air communication. Greater speed provides the opportunity of attracting a larger number of clients from other forms of transportation and other competing airlines. All criteria of economy proferred in foreign literature are attempts at an optimum between increased costs and a profitable increase in speed. In capitalist society the desire to conserve time is the private business of the individual.

"As for the individual," says Marx, "so for society, the all-round nature of its development, its consumption and its activity depends on the saving of time. All economy is in the final analysis reduced to an economy of time. Society must also distribute its time efficiently in order to achieve the level of production corresponding to its aggregate needs, just as an individual must distribute his time correctly to achieve knowledge in the appropriate proportions or to satisfy the various demands put on his activity. Therefore an economy of time, just like a systematic distribution of work time among the various branches of industry, remains the first economic law in the basis of collective production."*

In the conditions of socialist economy the desirability of increasing the speed of passenger hauls, naturally, is not determined by

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*Arkhiv Marksa i Engel'sa (Archives of Marx and Engels), Vol. IV, Partizdat, 1935, p. 119.

competition. The important thing for us is the economy of work time. The more work time is saved by air communication, the more desirable it is. Air transport, as the fastest means of communication, lessens work time lost in passenger hauls. This is its economic significance.

The prime cost of a haul and the required capital investments cannot wholly characterize the economic aspects of the various forms of passenger transport if they differ in speed. In order to correctly evaluate the economy of air travel, it is necessary to account for the economic effect of time saved.

Here a number of unsolved problems arise. First of all, it is necessary to find a common unit of measurement for production costs per unit of transport production and speed -- the qualities of transport production. Theoretically, work time could be such a common unit of measurement. The costs of transport production express work expenditures, and their volume is measured by the number of work hours spent on the production -- passenger-kilometers. These costs are different on various forms of transportation (they are usually higher on fast transport).

On the other hand, the travel time of passengers on industrial (business) trips represents a loss of work time for the society. The size of this loss is directly proportional to the distance, and inversely proportional to the speed of travel. Let us suppose that the speed of an air haul is ten times faster than one by railroad. This means that on a route covered by a plane in one hour, the economy of work time, in comparison to hauling a passenger the same distance by train, will be nine hours. Allowing that one hour of the passenger's work time is equal in quality to one hour of transport production -- passenger-kms -- we can give a comparative rating of the economy of various forms of passenger transport with an account for their speed.

This is very difficult to do in practice, because the value of a passenger's time can be very different. It depends not just on the salary he makes, but also on the importance of the trip. Besides, it is apparently more correct to give a monetary value to the passenger's lost work time not according to salary, because salary itself is not

equivalent to the production of a socialist society's worker during a unit of time, but rather with an account for the additional value created for common needs.

One should also keep in mind that the effectiveness of fast transport, and consequently the monetary equivalent of time saved by the passenger, asymmetrically approaches the limit, with an increase in speed. If, for example, with the existing means of transportation, the distance between two points is covered in 100 hours, then with a two-fold increase in speed, the economy in time will constitute 50 hours; with a further two-fold increase in speed it will be 25 hours; and with another doubling only 12.5 hours, etc. The limit, apparently, will be the total expenditure of time for the trip on some form of transport, as compared to instantaneous arrival at the destination. With existing jet speeds of around 1,000 kms/hour, a further increase in speed for distances under 3,000-2,000 kms would hardly be desirable, if it is accompanied by increases in material and work expenditures. A savings of another ten minutes by the passenger in flight is so insignificant that it will be difficult to evaluate it from an economic point of view.

The above-mentioned possible ways of evaluating the economic significance of faster hauls can only be applied to hauls of passengers traveling with productive (business) goals. For passengers traveling on personal business, an increase in social labor expenditures for speeding up their trip will mean an increase of the consumption share in the general national income, an increase in the well-being of the nation. "A saving in work time is equal to an increase in free time, that is, time for that complete development of the individual, which, in its turn, as the greatest productive force, influences again the productive power of work. From the point of view of a direct production process this saving can be viewed as the production of fixed capital; this fixed capital is man himself."*

*From unpublished writings of K. Marx, Bol'shevik, No. 11-12, 1939, p. 65 (Marx's emphasis).

The economic effect of the development of air communication and its becoming a means of mass passenger transport will also be felt in the more economic operations of other forms of transport (the railroads first of all), interacting with air transport. The capacity of multi-passenger express planes has reached large proportions, and exceeds by several times the capacity of trains.

With all passenger seats filled and an annual flight time of 1,800 hours, an Il-18 can complete 115 million passenger-kms a year; a Tu-114 -- 245 million passenger-kms. In order to serve the total passenger turnover between Moscow and Leningrad, which reaches approximately one million passengers annually, only five or six Il-18s would be needed. Calculations also show that seven or eight Tu-114s will be able to replace the daily runs of an express train between Moscow and Vladivostok, and free 20 trains, or 280 passenger cars, and 40 locomotives. But the most essential point lies in the fact that freeing railroad transport from a considerable part of its passenger hauls will allow it to increase the volume of freight hauls. This has primary significance in several respects. From an economic viewpoint, raising the railroads' capacity for hauling freight means a saving of capital investments earmarked for the reconstruction of the existing network, or postponing these investments to a later period.

The socialist economic system insures, through a strict planning of hauls, the possibility of a relative decrease, as compared to capitalism, in the costs of social labor expended on transport serving industry. But the degree of social labor expended to provide transport services for the personal needs of the population are incomparably larger under socialism than under capitalism. This should create favorable conditions for the development of air passenger hauls. Besides persons traveling on business, air transport will be utilized to an even greater extent by large elements of the population for trips of a personal nature. Besides serving a part of the passenger turnover that exists with the present speed of the various means of transportation, air transport will create a brand new

passenger flow. Because of the development of rapid air transport, people will be able to travel in their free time to places for which there was inadequate time in the past.

At present we can only theorize about the creation of a new passenger flow. It is somewhat premature to speak of its probable size. But one thing is sure: air transport will be a serious influence on the greater mobility of our nation's population, and will aid in raising the cultural level of our working people.

CONCLUSION

As a result of our analysis of the development of air transport we can draw the following conclusions:

- Air transport has reached that stage of development that allows it to become one of the major means of passenger transport in our nation. It is called upon to play a most important role in time savings in transporting our nation's working people, especially over long distances, serving the predominant part of all inter-regional passenger travel.

- A more complete meeting of the population's needs for rapid communication can be achieved through close cooperation of the various means of transportation and the organization of a mixed or combined air-railroad, air-water, and air-automobile passenger transport. This will allow for an increase in passenger air hauls, and effective utilization of the most economic multi-passenger planes on the major air routes. It is also rational to widen air transport's scope in serving intra-regional passenger and freight hauls in outlying oblasts of the nation, where planes and helicopters can become the means of pioneer transport for the initial exploitation of natural resources.

- The control figures for the development of the USSR national economy for 1959-1965 indicate that these seven years will be a period of fundamental technical reconstruction of the major types of transportation, especially rail and air. Air transport's share in serving the total passenger turnover will increase from 3.5 percent in 1958 to 15 percent in 1965.

- The introduction of new, efficient types of planes and helicopters, the reconstruction and broadening of the network of airports, and equipping the airlines with contemporary means of navigation will create all the conditions necessary for the further development of air transport. These actions of the current seven years will be of essential importance in the coming years also. Therefore,

all-round study of the various problems of air transport development in the distant future is a pressing current problem. It should attract the attention of scientific institutes and planning organs.